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Simpson, G. W., Holmes Hall, Orono, Me.
Singleton, J. M., Hidalgo, Texas.
Slack, Torbert, Box 773, Lake Charles, La.
Sleesman, Geo. B., Box 23, No. Glenside, Pa.
Slocum, Burl A., Univ. of Nanking, Nanking, China.
Smith, C. L., R. F. D. No. 5, Wesson, Miss.
Smith, F. A., Senatobia, Miss.
†Smith, Geo. A., Dept. Conservation, 20 Somerset St., Boston, Mass.
Smith, Geo. E., Albion, N. Y.
Smith, W. F., 1811 East Walnut St., Pasadena, Calif.
Spangenberg, Herbert, 137 N. San Joaquin St., Stockton, Calif.
Spawn, G. B., College Sta., Brookings, S. D.

†Members who attended 1933 meeting.

Spies, J. R., College Park, Md.
Stanley, W. W., Agric. Exp. Sta., Knoxville, Tenn.
Stanton, J. W., Box 994, Bellingham, Wash.
Steinweden, John B., Agric. Bldg., Mission at Embarcadero, San Francisco, Calif.
Stevenson, W. A., Box 1910, Tucson, Ariz.
Strand, Thomas P., c/o Cal. Spray Chem. Co., Yakima, Wash.
†Sullivan, Wm. N., 7710 Blair Rd., Takoma Park, Md.
Summerland, S. A., Bentonville, Ark.
Symonds, Clarence M., Bur. Ent., Melrose Highlands, Mass.

Talbert, T. J., Hort. Bldg., Whitten Hall, Columbia, Mo.
Tate, H. D., State College, Ames, Iowa.
Thompson, B. T., P. O. Box 514, Summit, N. J.
Thompson, Friar M., Jr., Hercules Powder Co., Wilmington, Del.
†Thompson, G. A., Box 187, Kingston, R. I.
Thompson, Robert W., Dept. Ent., O. A. C., Guelph, Canada.
Thompson, William L., Lake Alfred, Fla.
Thomson, J. R., Jr., Box 445, Ft. Valley, Ga.
Thurber, George A., State College, Ames, Iowa.
Tibbits, H. A., c/o Cal. Spray Chem. Co., Browns Valley, Yuba Co., Calif.
Townsend, James Farley, 278 Canner St., New Haven, Conn.
Townsend, Lee H., Div. Ent., Univ. of Ill., Urbana, Ill.
Toyne, Arthur, 404 Cypress Ave., Pasadena, Calif.
Travis, Bernard, Zool. Dept., I. S. C., Ames, Iowa.
Tubbs, Dixson W., Tustin, Calif.
Tuckett, James E., Indio, Calif.

Ulman, Paul T., European Corn Borer Control, Auburn, Ind.

VanAllen, Thomas S., 902 Charleston St., Mobile, Ala.
van der Meulin, P. A., Rutgers U., New Brunswick, N. J.
VanHorn, Clair, Room 1, Masonic Bldg., Meadville, Pa.
Vickery, R. K., 1118 Oxford St., Berkeley, Calif.
Vinzant, M. G., 1401 Buena Vista Ave., Laredo, Texas.
Vogel, Matthew A., Agric. Exp. Sta., Wooster, Ohio.

Wagner, Geo. B., Flour Mill Insect Lab., 1318 E. Armour Boulevard, Kansas City, Mo.
Walker, G. L., Durham, N. H.
Wallis, Robert L., Box 348, Estancia, N. Mex.
Warren, Allen J., 59 Lincoln St., New Haven, Conn.
Waters, Harold A., B. & Z. Bldg., O. S. U., Columbus, Ohio.
Watson, Lloyd R., Alfred, N. Y.
Watts, J. G., Clemson College, S. C.
Weed, C. M., State Normal School, Lowell, Mass.
Wells, Arthur B., Bryn Athyn, Pa.
Westgate, W. A., Durham, N. H.

†Members who attended 1933 meeting.

Whang, Won Yill, Haiku Pineapple Co., Ltd., Haiku, Maui, H. T.
†Whitten, Russell R., Melrose Highlands, Mass.
Wilbur, Donald Alden, Dept. Ent., K. S. C., Manhattan, Kansas.
†Wilford, B. H., Central State Forest Exp. Sta., Columbus, Ohio.
Willard, H. J., Moorestown, N. J.
Willey, C. R., Room 1112, State Office Bldg., Richmond, Va.
Williams, L. L., Box 253, Russellville, Ala.
Williams, V. E., 1324 Elm Ave., San Gabriel, Calif.
Williamson, Amis L., International Bridge, Hidalgo, Texas.
Wilson, G. R., 1538 Paru St., Alameda, Calif.
Winchester, H. J., R. D. 1, Wakefield, Mass.
Woke, Paul A., 808 No. Patterson Ave., Baltimore, Md.
Wolfenbarger, D. O., Dept. of Ent., Cornell Univ., Ithaca, N. Y.
Woodrow, A. W., Dairy Bldg., Cornell Univ., Ithaca, N. Y.
Woodruff, Laurence C., Roberts Hall, Cornell Univ., Ithaca, N. Y.
Woodside, A. M., 627 W. Frederick St., Staunton, Va.
Wray, David, L., Jr., Dept. Agric., Raleigh, N. C.
Wright, Percy F., 513 S. School St., Lodi, Calif.
Wygant, N. D., N. Y. St. College of Forestry, Syracuse, N. Y.

York, Converse H., 304 Madison Ave., Pomona, Calif.
York, Geo. T., P. O. Box 208, Modesto, Calif.
Young, H. D., Bur. Chem. Soils, Washington, D. C.

Zeinet, Carlo, Bur. Ent., Washington, D. C.

Total number of associate members, 427.

FOREIGN MEMBERS

Anderson, T. F., Nairobi, British East Africa.
Aullo, Costilla, Dr. Manuel, Laboratorio de la Fauna Forestal, Ferraz, 40 Madrid, Spain.

Ballou, H. A., West Indian Agricultural College, St. Augustine, Trinidad, West Indies.
Bordage, Edmond, Directeur de Musee, St. Denis, Reunion.
Brain, Charles K., University of Stellenbosch, Stellenbosch, C. P. South Africa.

Carpenter, Dr. George H., University of Manchester, Manchester, England.
Collinge, W. E., 55 Newhall St., Birmingham, England.

Danysz, J., Laboratorie de Parasitologie, Bourse de Commerce, Paris, France.
DeBussy, L. P., Kolonial Instit., Mauritskade 65–66, Amsterdam, Holland.

Escherich, K., Forstliche Versuchsaustalt, Universitat, Munich, Germany.

Filipjev, T. N., Gertzena 44, Leningrade, Russia.
Fredericks, Karl, Inst. Ent., Rostock, Germany.
French, Charles, Department of Agriculture, Melbourne, Australia.
Froggatt, W. W., 12 Young St., Croyden, Sydney, New South Wales.

†Members who attended 1933 meeting.

Grasby, W. C., 6 West Australian Chambers, Perth, West Australia.
Green, E. E., Way's End, Beach Ave., Cramberley, Surrey, England.

Harukawa, Chukichi, Kurashiki, Okayama-Ken, Japan.
Herrera, A. L., Care Secretaria de Agricultura y Fomento, Mexico, D. F. Mexico.
Hill, Gerald F., 5 Clifton Rd., Hawthorn, Melbourne, Australia.
Horvath, Dr. G., Museum Nationale Hungaricum, Budapest, Hungary.

Jablonowski, Josef, Entomological Station, Budapest, Hungary.
Jack, Rupert W., Salisbury, Rhodesia, South Africa.
Johnson, Thomas H., University of Brisbane, Queensland, Australia.

Kulagin, Nikolaie M., Petrovsky-Rasumovsky Academy, Petrovsko-Rasumovskoie, Moscow, Russia.

Lounsbury, Charles P., 795 Church St., East, Pretoria, South Africa.

Mally, C. W., University of Stellenbosch, Stellenbosch, C. P., South Africa.
Marchal, Dr. Paul, 16 Rue Claude-Bernard, Paris, France.
Mokrzecki, Dr. Sigismund, Director Instit. of Forest Protection and Entomology, Skierniewice, Poland.

Mussem, Charles T., Hawkesbury Agricultural College, Richmond, New South Wales.

Nawa, Yashushi, Entomological Laboratory, Kyomachi, Gifu, Japan.
Newstead, Robert, University School of Tropical Medicine, Liverpool, England.

Parker, Theodore, Leeds University, Leeds, England.
Porter, Carlos E., Casilla 2352, Santiago, Chili.
Pospielow, Dr. Waldemar, Bureau of Entomology, Morskaya 44, Petrograd, Russia.
Read, Charles S., Mendoza, Argentine Republic, South America.
Rosenfeld, A. H., Cotton Research Board Bldg., Giza, Egypt.
Ruzkowski, J. W., Solacka, Poznan, Poland.

Sajo, Prof. Karl, Godollo-Veresegyhaz, Hungary.
Scaramuzza, L. C., Santiago de las Vegas, Cuba.
Schoyen, Prof. W. M., Zoological Museum, Oslo, Norway.
Severin, Prof. G., Curator Natural History Museum, Brussels, Belgium.
Silvestri, Dr. F. R., Scuola Superiore di Agricoltura, Portici, Italy.
Soudek, Stepan, College of Agric., Brno, Czechoslovakia.
Stellwaag, Dr. Frederich, Neustadt, a. d. Haardt, Germany.

Theobald, Frederick V., Wye Court, Wye, Kent, England.
Thompson, Rev. Edward H., Franklin, Tasmania.
Tillyard, R. J., Cawthron Institute of Scientific Research, Nelson, New Zealand.
Tragardh, Ivor, Experimental Faltat, Stockholm, Sweden.
Trouvelot, Bernard, Inst. Agr. Research, Paris, France.
Tryon, H., Queensland Museum, Brisbane, Queensland, Australia.

Urich, F. W., Department of Agriculture, Port of Spain, Trinidad, West Indies.

Zander, Enoch, Landesinstit fur Bienenzucht, Erlangen, Germany.

Total number of foreign members, 52.
Life Members, 6.
Grand Total of Members, 1161.

JOURNAL
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OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

VOL. 27 FEBRUARY, 1934 No. 1

The Proceedings of the Forty-Sixth Annual Meeting of the American Association of Economic Entomologists

The 46th annual meeting of the American Association of Economic Entomologists was held in the Hotel Bradford, Boston, and in Austin Hall, Harvard University, Cambridge, December 27–29. The registered attendance was approximately 170 members and 75 visitors.

On Wednesday afternoon, December 27, the program of the Section on Plant Quarantine and Inspection and that of the Section on Apiculture were scheduled in the Hotel Bradford.

Wednesday evening was devoted to the program of the Section of Extension and also a Beekeepers' Smoker, both in the Hotel Bradford.

On Thursday morning, December 28, in Austin Hall, Harvard University, the program of the main Association opened with the transaction of routine business, reports of committees, etc., and the annual address of the President on "Some Achievements in Economic Entomology." The afternoon was devoted to the reading of papers, the program being run in two concurrent sessions in Austin Hall.

Friday morning, December 29, was occupied in the reading of papers; the entire session devoted to the subject of insecticides and spray chemicals. The afternoon session was devoted to a symposium on the Spray Residue Problem which attracted a large number of visitors as well as members of the Association. At the close of the symposium the main Association held its final business session, and the 46th Annual Meeting was adjourned at 6:30 P. M.

By arrangement between Mr. E. J. Rowell and the Secretary, the facilities of station WBZ were procured for three broadcasting periods during the course of the meeting. The speakers, President Hinds and Messrs. Felt and Burgess, acquainted the radio audience with the work and purposes of this Association and discussed entomological subjects of timely interest.

It was voted that the next Annual Meeting be held in conjunction with that of the American Association for the Advancement of Science in Pittsburgh, Pa., December, 1934.

The Entomologists Dinner was held in the Salon of the Hotel Bradford on Thursday Evening, December 28 with an attendance of 175. Dr. W. E. Britton acted as toastmaster and an interesting program was presented. The dinner and speaking were followed by the annual address before the Entomological Society of America by Dr. Lutz of New York City.

Twenty-eight new members were elected and three reinstated to membership in the Association.

Dr. E. F. Phillips of Ithaca, N. Y., was elected President for the year 1934.

PART I. BUSINESS PROCEEDINGS

The first business session of the Forty-Sixth Annual Meeting of the American Association of Economic Entomologists convened on Thursday morning, December 28, 1933, at ten o'clock, in Austin Hall, Harvard University, Cambridge, Massachusetts, Dr. W. E. Hinds, President of the Association, presiding.

PRESIDENT HINDS: The Forty-Sixth Annual Meeting of the American Association of Economic Entomologists will please be in order.

I am sorry that the delay of connection in getting out here puts us somewhat late at the start. We will be just as prompt as possible with the regular routine reports. The first report is that of the Secretary, Mr. Bourne.

REPORT OF THE SECRETARY

The membership at the Atlantic City Meeting was 1234, comprising 618 active members, 565 associate members and 51 foreign members.

The present membership is 1214, listed as follows: active 645; associate 519; foreign 50; life members 6. These changes are due to the elections, the customary alterations in class of members, resignations, deaths and loss due to non-payment of dues.

There are at present 26 active and 61 associate members who will be dropped January 1st unless their outstanding dues are paid.

The pressure of the economic depression coupled with many unique features which have made the past year a memorable one has seriously affected a large proportion of our members, and in turn has been reflected in the affairs of the Association.

The records available indicate an unusually heavy toll by death on our membership during the past year. Since the preparation of the last report word has been re-

ceived of the death of five active, four associate and one distinguished foreign member as well as of three former members of the Association.

George W. Ellington of Silver Spring Maryland, died on August 23, 1932. He was a graduate of the Mississippi A. & M. College in 1922 and had since that time been connected with the United States Bureau of Entomology in the research on insect pests of Stored Food Products. He was a young man of great promise and his passing is deeply regretted.

Alonzo W. Lopez, an associate member of this Association, died following treatment for tuberculosis in Monrovia, California, November 2, 1932. He received his Bachelor's Degree at the University of California in 1926 and his Master of Science from the same institution in 1928. Through a portion of this time he served as Technical Assistant to Dr. Herms at Riverside. In 1929 he was appointed Entomologist in charge of the Philippine Sugar Association, with headquarters at La Carlota Central, Philippine Islands, a position which he held until forced by ill health to return to his home shortly before his death.

Edgar M. Ledyard died at his home in Salt Lake City, Utah, on March 6, 1933. He was for several years engaged in educational work in the Philippines. He secured his Master's Degree from the University of California in 1914 and the following year entered the employ of the United States Smelting, Refining and Mining Company as Agricultural Director of the Company's experimental farm. He later turned to the manufacture of insecticides and fungicides and developed several successful weed killers from by-products of smelting operations. His many and varied interests extended beyond the field of his professional work. In some of these he won national recognition. His death is deeply regretted.

Dr. Norman Criddle, for years an active member of this Society, died on May 4, 1933, after having failed to rally from an operation on April 28. A man of great talent and of varied interests in the realm of natural history, he served in various capacities in the Dominion Service in Manitoba. His outstanding work in Economic Entomology was in his successful work in grasshopper control and the development of the Bait Mixture which bore his name.

Dr. Clarence R. Phipps died in the Eastern Maine Hospital in Bangor on June 21 following an emergency operation on the previous day. His entomological training was secured at Massachusetts Agricultural College, followed by graduate work in Iowa State College and Cornell University where he received his Doctor's Degree in 1930. He was for a short period on the staff of the Agricultural Experiment Station at Geneva, New York; later in similar work at the Fruit Experiment Station in Missouri. From 1925 up to the time of his death he was engaged in entomological research chiefly on fruit pests in the Maine Experiment Station. His work won the appreciation of fruit growers in his state and his publications merited the praise of his colleagues. His many friends have felt a deep personal loss in his untimely death.

Prof. F. Eric Millen, a prominent member of the staff of the Ontario Agricultural College, died at his home on July 14, 1933. He graduated from the Ontario Agricultural College in 1913 specializing in entomology with his chief interest in apiculture. He was engaged in apicultural work at both the Michigan and Iowa State Colleges and in 1919 returned to Ontario as Provincial

Apiarist. During the fourteen years of service in that province he came to occupy a high place in the esteem of his colleagues and exerted an influence in his particular field that extended far beyond the boundaries of his province.

Dr. Shinkai Inokichi Kuwana, the eminent Japanese Entomologist and a foreign member of this association, died of heart failure in Tokyo, Japan, July 14, 1933. From 1895–1897 he was a student of Entomology at Cornell University. In 1897 he entered Stanford University where he received the A. M. Degree in 1901, later returning to Japan. During his years in New York and in California he made many acquaintances among entomological workers which formed the basis of his wide personal friendships in this country. He was for many years in direct supervision of the quarantine work at Yokohama and was later Chief Entomologist of the Ministry of Agriculture and Forestry with headquarters at Tokyo. He was nominated for foreign membership in this association by Dr. L. O. Howard in 1909. His excellent publications, particularly in his special field of the Coccidae won him international recognition. High honors were conferred on him by the Emperor of Japan, in recognition for his valuable services.

Dr. Robert E. Wall, Assistant Entomologist of the Montana Experiment Station since 1931, died at Eveleth, Minnesota, July 29, 1933, at the age of 30. He was graduated from the Colorado Agricultural College in 1924 and later attended the University of Minnesota where he received the degree of Doctor of Philosophy in 1930. He served for brief periods in Lignan University, Canton, China and at De Pauw University, before taking up his work in Montana. His untimely death brought to an abrupt close what promised to be a brilliant career and his death is deeply regretted by his wealth of personal friends.

Argyle B. Proper died at his home in Melrose Highlands on Sunday, December 17, 1933, after a brief illness. He was a graduate of the University of New Hampshire and had for several years been connected with the United States Bureau in the Gypsy Moth Parasite Laboratory at Melrose Highlands.

Word was recently received through the Postal authorities of the death of E. F. Grossman, an active member, at his home in New York City.

Dr. Frederic W. Goding, a former member of the Association, died at his home in Livermore Falls, Maine, on May 5, 1933. He was particularly well known for his systematic work on the group Membracidae. He was at one time United States Ambassador to Ecuador.

Raymond L. Nougaret died suddenly of heart failure in Smyrna, Turkey, Jan. 10, 1933. He was for several years a member of the United States Bureau of Entomology where his chief work was on Grape Phylloxera. Much of this time was spent in California, where he was engaged in a study of Grape Insects, after leaving the Bureau. In 1931 he went to Turkey to reorganize and restore the raisin industry there. Official recognition of the success of his work and appreciation of his service was made by the Turkish Government at the time of his death.

Fred E. Brooks, for many years a member of the American Association of Economic Entomolgists and a charter member of the Entomological Society of America, died on March 9, 1933, of heart failure after several years of ill health. From

1902–1911 he was on the staff of the West Virginia Experiment Station. From 1911–1928 he was a member of the Bureau of Entomology in the Division of Fruit Insect Investigations, in West Virginia. His best known work was on various species of wood boring insects, particularly the round headed apple tree borer.

Cotton States Branch

The 8th Annual Meeting of the Cotton States Branch was held at New Orleans, La., on February 2 and 3, 1933, Dr. J. W. Folsom presiding. The meeting proved to be one of the best the Branch has held and the attendance unusually good, particularly in view of present conditions. A very interesting program comprising 22 papers occupied two complete sessions. A pleasant feature of this meeting was the opportunity of extending a welcome and congratulations to the newly elected President of the main Association, Dr. W. E. Hinds.

The following officers were elected:

Chairman—R. W. Leiby, Raleigh, N. C.
Vice Chairman—S. W. Bilsing, College Station, Texas.
(The Sec.-Treas.—O. I. Snapp was elected in 1931 for a 3-year period.)

Pacific Slope

The 18th Annual Meeting of the Pacific Slope Branch was held at the Utah State University, Salt Lake City, Utah, June 14 and 15, 1933. Reading and discussion of papers occupied the morning of the 14th and the entire day of the 15th. On the afternoon of the 14th, the visiting entomologists were conducted on a field trip by George I. Reeves and his staff, who demonstrated the work on Alfalfa Weevil.

The Annual Dinner was held on the evening of June 14. The total attendance was 46. The following were elected for 1934. President—G. I. Reeves. Vice-President—W. B. Herms. Secretary—H. A. Scullen.

Eastern Branch

On December 30, 1932, the Eastern Branch held a joint session with the general Association in connection with the Atlantic City Meetings, with Vice-President L. M. Peairs presiding. Eight papers were presented by members of the Eastern Branch; the remainder of the program being occupied by invitation papers on the Codling Moth and Its Control by Messrs. Parrott, Ackerman, Flint and List.

T. J. Headlee of New Brunswick, N. J., was elected Chairman and H. B. Weiss of Trenton, N. J., Secretary for three years.

On November 23 and 24, 1933, the Eastern Branch held its Annual Meeting in the Academy of Natural Sciences in Philadelphia, Pa. A two-day program comprising 45 papers was presented. The meeting was very successful; and the papers of timely interest. The average attendance at the sessions was 135–150. The facilities offered by the Academy of Natural Sciences were very satisfactory and much appreciated. Dr. L. A. Stearns of Newark, Delaware was elected Chairman and Prof. T. L. Guyton of Harrisburg, Pa., Vice Chairman.

Chicago Meeting

A special Summer Meeting of the American Association of Economic Entomologists was held in conjunction with the American Association for the Advancement of Science and other affiliated societies, in connection with the Century of Progress Exposition in Chicago, Illinois.

The special meeting of this Association comprised a joint session with the Entomological Society of America on June 22nd and 23rd, 1933.

As a result of the program of the American Association for the Advancement of Science, during the same week, members of this Association were offered the privilege of meeting several biologists of note from abroad, especially during the afternoon program of June 23rd and at the general reception on Friday evening, June 23rd.

A joint session of Section F of the American Association for the Advancement of Science with affiliated Entomological Societies, this Association and the Entomological Society of America was convened in the Field Museum on June 22nd. This Association was honored by the invitation extended to its President, Dr. W. E. Hinds, to preside at the opening of this session, which featured an address by Dr. R. J. Tillyard of Canberra, Australia, on "The Evolution of Insects."

At the joint banquet of the two Entomological Societies on the evening of June 23rd, President Hinds, on behalf of this Association, presented Prof. W. P. Flint a Past President's diploma in appreciation of his able leadership during the previous year.

Announcement was also made at this time of the appointment of a special committee for the investigation of the proposed reorganization of entomological research in the Federal Government, and a preliminary report of progress to that time was presented by the Chairman, Dr. E. F. Phillips.

By vote of that meeting, this committee was authorized thereafter to act also in behalf of the Entomological Society of America, the expenses to be met jointly by the two organizations.

Indices to the Literature of American Association of Economic Entomology

Indices I and II:

Sales of these volumes during the past year have totalled $35.00.

Index III:

The sales of this volume have totalled $40.00.

Index IV:

The sales of this index have dropped to $76.00.

An ample supply of all numbers is available. The sales of the past season have left the indebtedness of volumes III and IV at practically the same figure as last year.

Sales at present are practically limited to libraries and to foreign orders. No increase in price has been made and it is hoped that as conditions improve more and more members will add these volumes to their libraries.

JOURNAL OF ECONOMIC ENTOMOLOGY

Volume 26 of the Journal of Economic Entomology has just been completed and contains 1201 pages, being exceeded only by volumes 24 and 25, in size.

By means of the strictest economy and a surprising steadiness in the domestic subscriptions, it has been possible to print the volume with the present subscription price even in the face of many cancellations, for economic reasons. Additional support has been rendered through advertising and the payment by authors for papers in excess of six pages, or for the privilege of early printing.

Complete sets of the Journal are still available, except as listed in the advertising section of each issue. Prices have not been advanced for back numbers. A considerable proportion of the sales during the past year have been to foreign libraries or Government Stations.

With practically the same Geographical Distribution as last year, the present (December) subscription list consists of United States 1251, United States Island possessions and Canada 81, Foreign 321, a grand total of 1653 compared with 1779 in 1932.

There is attached hereto a statement of the cash received and disbursements made by the Association, Journal, Index Accounts and also of the Permanent Fund. This has been audited by Ernest L. Millington, State Accountant, Springfield, Mass.

Respectfully submitted,

A. I. BOURNE,
Secretary.

STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

For the period from November 30, 1932, to December 9, 1933

	Total	Journal	Association	Index IV	Index III	Index I and II
Balance, Nov. 30, 1932 per previous report..	$5,903.53	$3,581.44	$1,488.64	$123.32	$54.01	$656.12
Income						
Sales	151.00			76.00	40.00	35.00
Subscriptions, advertising and miscellaneous	6,316.46	6,316.46				
Dues and separates...	1,339.62		1,339.62			
	13,710.61	9,897.90	2,828.26	199.32	94.01	691.12
Less checks returned during bank closures in March	449.42	280.90	168.52			
Net income	13,261.19	9,617.00	2,659.74	199.32	94.01	691.12
Expenses:						
Auditing	35.00		35.00			
Printing	4,987.66	4,906.56	81.10			
Clerical work	483.00	335.00	148.00			
Editor's Salary	200.00	200.00				
Postage	189.24	98.63	90.61			
Telegraph, freight and express	52.86	25.69	27.17			

STATEMENT—*Continued*

Expenses: *Continued*						
Secretary's salary	200.00	100.00	100.00			
Half tones and engravings	962.58	962.58				
Supplies and Stationery	1.50	1.50				
Surety bond of secretary	12.50		12.50			
Expenses of special committee	215.85		215.85			
Branch secretaries expenses	37.04		37.04			
Stenographic report ..	145.76		145.76			
Contribution to Biological Abstracts ..	100.00		100.00			
Association badges ...	18.81		18.81			
Bank collection charge	.20		.20			
Federal check tax	1.00	.50	.50			
Net expenses	7,643.00	6,630.46	1,012.54			
Balance Dec. 9, 1933 ...	$5,618.19	$2,986.54	$1,647.20	$199.32	$94.01	$691.12

The balance is on deposit at the:

First National Bank, Amherst, Mass.	$2,608.29
First National Bank, Malden, Mass.—Certificate of Deposit	3,000.00
Cash on hand, verified	9.90
	$5,618.19

Redemption of checks returned during bank closure to Dec. 9, 1933 ..... $195.62

PERMANENT FUND AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

For the period from November 30, 1932, to December 9, 1933

Balance, November 30, 1932, per previous report			$14,534.28
Additions			
Interest from securities		$546.25	
Interest from savings deposits		62.28	
Interest from Index, Journal and Association accounts		38.05	646.58
Balance, December 9, 1933			$15,180.86
Invested as follows:			
Par Value			
1500	United States Liberty Bonds 4¼%	$1,500.00	
5000	United States Liberty Bonds 4¼%	4,960.00	
4000	Federal Land Bank of St. Louis 4¼%	3,550.00	
2000	Province of Ontario 5%	2,000.00	$12,010.00
Bank Deposits			
Savings Bank			
Amherst Savings Bank		$2,173.36	
Savings Department, Trust Company			
Franklin Trust Company, Greenfield, Mass.		997.50	3,170.86
			$15,180.86

Audit of the accounts of the American Association of Economic Entomologists covering period from November 30, 1932, to December 9, 1933.

Receipts as recorded in cash book verified.

Cancelled checks compared with recorded payments and vouchers examined.

Balance, per cash book, verified with statement from First National Bank, Amherst, Mass., certificate of deposit First National Bank, Malden, Mass., and cash in hands of secretary.

Income from Permanent Fund, and balance, as shown in report, verified by examination of bank books and securities.

Appended is a schedule of receipts and payments for the audit period showing cash balance in hands of the Treasurer December 9, 1933, and a statement of the income during the period and condition of the Permanent Fund, December 9, 1933.

Springfield, Mass. ERNEST L. MILLINGTON,
December 10, 1933 *State Accountant*

Upon motion regularly made and seconded, it was voted that the Report of the Secretary be adopted.

REPORT OF EXECUTIVE COMMITTEE A. A. E. E.

Boston, Mass., Dec. 28, 1933.

In accordance with usual custom, plans were made for the annual meeting of the Association to be held at Boston, Mass., December 27 to 29, 1933.

Committee on Local Arrangements for the Boston meeting: Chairman C. W. Collins, with Dr. C. T. Brues and Mr. W. D. Whitcomb.

At Atlantic City it was voted to hold a summer meeting at Chicago during the latter part of June in conjunction with the A. A. A. S. meetings there. Committee on Chicago meeting, local arrangements: Chairman W. P. Flint with Dr. C. L. Metcalf and Professor J. J. Davis. After full consideration, meetings were scheduled for June 22 and 23. A profitable and enjoyable meeting was held.

The Association was invited to appoint delegates to the Centennial Anniversary of the Entomological Society of London, for their meeting on May 4, 1933. The President appointed Dr. H. L. Parker, Hyerés, France, and Dr. E. C. Van Dyke as delegates. Dr. Van Dyke attended the Centennial. For this meeting a special message of greeting on parchment was prepared and presented by Dr. Van Dyke.

Dr. Don C. Mote, Dr. R. L. Webster and Dr. J. M. Swaine were appointed as delegates to represent the Association at the Fifth Pacific Science Congress, meeting in British Columbia, June 1–13, 1933.

In accordance with recommendations from the last annual meeting, a committee to continue consideration of the publication policy of the Journal of Economic Entomology was appointed with Professor H. J. Quayle, chairman, and Dr. C. L. Metcalf and Mr. A. F. Burgess. If this matter is not settled finally at this session, we recommend that the President for 1934 continue the committee.

Early in April, rumors were heard to the effect that Federal appropriations for state work in experiment station and extension services were likely to be seriously cut. Your President therefore took the responsibility of addressing telegrams to five influential parties in the Administration and in the Department of Agriculture, especially, protesting against cuts that might seriously hamper or limit the

work in these important fields. The Secretary of the Pacific Slope Branch also reported action taken from the West; the Extension Section of this Association, and the American Sugar Cane League cooperated with messages and letters.

In May it became apparent that vigorous action should be taken in behalf of the Association to prevent drastic curtailment of funds for investigational work in the Bureau of Entomology, and a threatened breaking up of the work and scattering it among various other divisions in the Department of Agriculture. Your President, therefore, appointed a special committee on Maintenance of Entomology in the Department and in the states, with Dr. E. F. Phillips, chairman, and Drs. W. E. Britton, E. P. Felt, E. N. Cory, and Professor J. S. Houser. At the Chicago meeting the Entomological Society of America voted that this same committee represent that Society also. This committee has been very active, and we believe effective, in insuring the maintenance of work in Entomology as a single administrative unit within the Department of Agriculture. This we believe to be of fundamental importance to the profession as a whole.

Another special committee on Publicity for Entomology, was appointed, with Dr. E. P. Felt, chairman, and regional representatives including Professor J. J. Davis, Dr. E. N. Cory, Professor W. B. Herms, Dr. Wilmon Newell, Mr. Clay Lyle and Mr. A. Gibson. The Executive Committee recommends that the Nominating Committee report nominations for 7 members for this committee for a period of 3 years to give the idea time for a fair trial.

At Chicago, in June, the Plant Pathologists appointed a committee on Plant Quarantine and requested the Entomologists to appoint a similar committee to cooperate with their committee in giving full consideration to this matter, with a view to establishing all quarantine work on a sound, scientific, biological basis. After rather extensive correspondence, it developed that the National Plant Quarantine Board has fully considered this matter and published a statement of Principles which seems to cover the ground very satisfactorily. An opportunity for public hearing on these matters was presented by the Bureau of Plant Quarantine in October and an extensive publication on quarantine matters by California authorities appeared at about this time. It seemed advisable therefore to withdraw all appointments for a quarantine committee in behalf of the Entomologists and the Plant Pathologists were so advised.

In behalf of the program plans for the meeting at Boston, it seemed that a symposium section on the general subject of "poisonous spray residues and arsenical substitutes" would be of interest and the Secretary was therefore instructed to arrange this in the program.

Inasmuch as both the Entomological Society of America and the Economic Entomologists are equally interested in the matter of Insect Collections, we recommend that this Committee be made a joint committee with each organization electing each year one member to serve for a term of three years, provided that this recommendation meets with the approval of the Entomological Society of America.

The next International Congress of Entomology is to meet in Spain in 1935. The Executive Committee favors the immediate setting up of a Committee on Arrangements for American participation therein and recommends that the president elected for 1934 appoint such a committee in the near future.

Inasmuch as a large group of Economic Entomologists usually participate in the Biologists' Smoker, we recommend that this Association, through its secretary, share in the expense therefor, in a sum not to exceed fifteen dollars.

W. E. HINDS, *President*,
For the Executive Committee

Upon motion duly seconded, it was voted that the report of the Executive Committee be adopted and filed.

REPORT OF THE REPRESENTATIVE TO THE NATIONAL RESEARCH COUNCIL

In the absence of Dr. Riley, no report was presented.

THE CROP PROTECTION INSTITUTE

Report for the year 1933

By W. C. O'KANE, *Chairman, Board of Governors*

In the course of 1933 the Crop Protection Institute has administered nineteen full-time and part-time research projects, and is now organizing two additional full-time research projects, funds for which have been deposited with the Institute.

These various projects, with the name of the supporting company, and the location of the work, are as follows:

(1) Development of new oil sprays, The Standard Oil Co. (Indiana), headquarters at the Illinois experiment station.

(2) Investigations in plant introduction and culture, the Standard Oil Co. of New Jersey, directing headquarters at the New Jersey experiment station and location of work principally in Pennsylvania.

(3) Flotation sulphur, The Koppers Co. of Pittsburgh, location of work largely at the Illinois experiment station. This project was brought to a close this year.

(4) Methods of extraction of pyrethrum, J. C. Makepeace, the work chiefly located at the Massachusetts sub-station at Wareham, Mass.

(5) New organic insecticides, the Dow Chemical Co., headquarters at the Iowa experiment station but supplementary work in several states.

(6) Development of new organic insecticides, the Sharples Solvents Corporation, part of the work at the Ohio experiment station and part at Philadelphia.

(7) Carbon dioxide in fumigation, the Liquid Carbonic Corporation, technical studies at the Iowa experiment station and engineering studies at Chicago and elsewhere.

(8) Investigation of new copper fungicides for use in connection with oil sprays, the California Spray-Chemical Corporation, New Jersey experiment station.

(9) New organic insecticides, the National Aniline and Chemical Co., part of the work at the New Hampshire experiment station and part in Florida and Mississippi.

(10) New organic fungicides, the National Aniline and Chemical Co., headquarters at the Delaware experiment station.

(11) New organic insecticides, the Halowax Corporation, the major part of the work at Ohio State University and part in Florida.

(12) New copper fungicides, the Nichols Copper Co., Delaware experiment station.

(13) Copper in plant nutrition, the Nichols Copper Co., Delaware experiment station.

(14) Fundamental studies of sulphur as a fungicide, the Freeport Sulphur Co., Delaware experiment station.

(15) Sulphuric acid in weed control, the Freeport Sulphur Co., the work chiefly in California, with headquarters at Davis, sub-station of the California experiment station.

(16) Carbon disulphide combinations in connection with insecticides, the Stauffer Chemical Co., project just starting with headquarters at the Connecticut experiment station at New Haven.

(17) Carbon disulphide in combination with fungicides, the Stauffer Chemical Co., the work just being organized with headquarters at the Massachusetts experiment station.

All of the above are full time projects. In addition to the above the following exploratory part-time projects have been under way:

Combinations of various organic chemicals with Penetrol, Alfred G. Kay, work in progress at the Ohio experiment station and the New Hampshire experiment station.

Exploration of new insecticides and fungicides, the Monsanto Chemical Co., work at the Delaware experiment station and the New Hampshire experiment station.

Extracts of pyrethrum and of derris, S. B. Pennick & Co., preliminary work so far at the New Hampshire experiment station.

New copper compounds, the Shepherd Chemical Co., location of work not yet determined.

In the case of each project technical direction is placed by the Institute in charge of a special project committee, in accordance with Institute custom. General supervision of all of the research work lies with the Institute Board of Governors.

The Institute has distributed this year six research bulletins as follows:

No. 37, Insecticidal Studies of Midcontinent Distillates as Bases for Pyrethrum Extracts—Household Sprays, by Henry H. Richardson.

No. 38, Notes on Rotenone as an Insecticide, by Neely Turner.

No. 39, Formation of Callus Knots on Apple Grafts as Related to the Histology of the Graft Union, by John E. Sass.

No. 40, Reducing Inflammability of Fumigants with Carbon Dioxide, by R. M. Jones.

No. 41, The Efficiency of Certain Proprietary Oil Emulsions, Volck and Orthol-K, for Control of the Oriental Fruit Moth, by Donald MacCreary.

No. 42, A Precise Method for Determining the Toxicity of Mixed Gases to Insects, by R. M. Jones.

Upon motion regularly made and seconded, it was voted that the report be adopted.

REPORT OF THE TROPICAL PLANT RESEARCH FOUNDATION

There is little to report in addition to that given last year as conditions for the foundation are essentially as they were at that time. The organization has been maintained intact and with a small reserve in the treasury. Dr. William Crocker continues to serve as Scientific Director (without salary) and the library files, etc., are stored at the Boyce Thompson Institute. Dr. Crocker has recently been requested by the Government of Ecuador to consider the possibility of aiding in the study and control of certain diseases of their cacao crop. No final results are to be reported. The request may be taken as an encouraging sign of future development. No new projects have been undertaken during the year.

Respectfully submitted,

HERBERT OSBORN.

Upon motion regularly made and seconded, it was voted that the report be adopted.

PRESIDENT HINDS: The next report is that of the Representative of the Council of the Union of Biological Societies.

PROFESSOR CROSBY: I regret I have no report to make. I was unable to attend the meeting a year ago. The meeting that should be held at this time has been postponed until next May.

It was voted that this committee be continued and report at next Annual Meeting.

PRESIDENT HINDS: Report of Committee on Nomenclature.

Mr. J. A. Hyslop was not present. No report was presented.

REPORT OF THE ENDOWMENT COMMITTEE A. A. E. E.

For several years, the present Endowment Committee has given careful consideration to its functions and problems The present Chairman has held a number of conferences with the former Secretary of the Association who was also the former Chairman of the Committee. The problems have also been informally discussed with a number of Past Presidents and other representative members.

As a result of these conferences and considerations, the Endowment Committee has crystallized its own thoughts and arrived at definite conclusions which are herewith reported.

To begin with, the Committee found that there was no official answer to the question as to why additional funds were needed. If we consider that other than the sale of life memberships—which, under present economic conditions may be considered as having reached a saturation point—the only means of obtaining additional endowment funds is by solicitation, the answer to this question is of vital importance.

It is, as would be expected, far more difficult to obtain endowments for self-supporting organizations than it is for those that are unable to meet current ex-

penses. The American Association of Economic Entomologists has been meeting expenses. Inasmuch as one of the basic reasons for solicitation of endowment contributions is, therefore, non-existent, the Committee finds itself unable to show the need of any additional contributions.

Apparently, no plans have been made for the use of such funds. No estimate has been made of amounts needed. No list of projects is available for presentation to prospective contributors. To solicit funds without having specific needs is, evidently, not business-like; and in these days is not likely to yield satisfactory results.

The Committee is also impressed with the fact that there is a very definite feeling among some of the members, that the Association should not maintain or add to the Permanent Fund.

In view of all the above considerations, the Endowment Committee submits the following recommendations:

1—That the Executive Committee, or other authorized body, arrive at a definite decision as to whether an Endowment Fund is needed.

2—That, in the event this question is decided in the affirmative, a statement be worked out on a project basis with estimates made of the amounts ultimately desired for each specific project.

3—Pending such decisions and the final presentation, if any, of a definite long-range plan covering specific projects—which the present Committee believes will take several years—this Committee recommends that it be discontinued.

Respectfully submitted,
G. A. DEAN
J. G. SANDERS
V. I. SAFRO, *Chairman*

G. A. DEAN on behalf of the committee pointed out the present lack of a definite purpose for which the endowment fund would be used and emphasized the necessity for the formulation of a definite specific program before any committee could interest persons to make substantial donations for such an endowment fund.

Further discussion by Messrs. Britton, Felt and Flint pointed out some of the purposes for which the present Permanent Fund of the Association was designed.

W. C. O'KANE: I think there is some confusion between the permanent fund and the endowment fund. Any association likes to think of an endowment fund in general terms of having a large substantial fund. We think, of course, of Rockefeller Foundations and Carnegie Institutions, and things of that kind. We think it would be very nice if a wealthy man would set up $100,000 or a half million dollars or more as an endowment fund for this Association on general principles, knowing how worthy the Association is.

I think the Committee is exactly right, that you cannot possibly approach either a corporation or an individual at any time, let alone these times, with the suggestion that they part with a substantial lot of money, unless you can show them very definitely what it is going to be used for and what the necessity of it is. However, our permanent fund as we have been building it up has been simply a matter of forehandedness. We have been able to lay aside some money from year to year to add to that permanent fund, the accumulation of interest, and so on.

An endowment fund, to amount to anything, means a very much larger sum of money than our permanent fund could ever amount to in the lifetime of anybody here or his heirs and successors. We certainly have to have the objective first. I wish we might keep distinct the possible use of income from this present permanent fund or any possible accretions to it we can see that might take place from year to year, and the idea of endowment fund which would run many many times as great as this little permanent fund of ours, to be adequate at all.

If the Executive Committee has not studied this matter of objectives, it would seem to me that committee should bring in a report to this Association as to the proposed objectives and that report should have the backing of an affirmative vote of this Association as the first step toward the possibility of securing an endowment.

So if the recommendation of the Committee can be made to read that the Executive Committee be asked to report to the next meeting its judgment as to the objectives of an endowment fund, it seems to me we take the next necessary desirable step.

It was regularly voted that the report be accepted, that the Executive Committee for 1934 be especially charged to bring in a statement of policy or purposes regarding endowment and that pending such a report the present committee on endowment be discharged.

REPORT OF THE BOARD OF TRUSTEES OF THE PERMANENT FUND

During the past year the fund has been increased by the income from securities, savings deposits and from the interest from the Index, Journal and Association accounts. No transfer from other funds was made from the Association or from the Journal. The fund has been audited and the report of Ernest L. Millington, State Accountant, will be found with the other financial transactions of the Association.

Respectfully submitted,

A. I. BOURNE, *Chairman* W. E. HINDS
H. B. HUNGERFORD C. L. MARLATT
A. F. BURGESS

By vote of the Association this report was adopted.

SUMMARIZED DATA ON PRIVATE COLLECTIONS

Name and address	Groups represented	Geographical distribution of collections	No. specimens in collection	No. species in collection	No. types in collection	No. types other than true types	Is collection available to other workers	Plans for disposition of collection	Will you determine species in your specialty
Clarence O. Bare, P. O. Box 1525, Sanford, Fla.....	Notonectidae, etc. (Hemiptera)	N. & S. America especially Florida	4,000	841		272	Yes[1]	Probably Univ. Kansas	Yes
A. E. Brower, Bar Harbor, Me.....	Lepidoptera	N. America	10,000	?	None	Few	Not at present	No plans	In genera Catocala and Cerura
Chas. R. Ely, 6 Kendall Green, Washington, D. C.....	Lepidoptera	90% from Connecticut	8,500	1,500	None	15	Yes	U. S. National Museum	In Gracilaria
Henry Fox, Moorestown, N. J.....	Orthoptera Coleoptera (Scarabaeidae)	Eastern United States	?	?	None	None	Yes		Yes
T. H. Frison, Nat. Hist. Survey, Urbana, Ill.....	Hymenoptera especially Bremidae and Evaniidae	World	10,000	280	38	166	Yes	Ill. Nat. Hist. Survey	In Bremidae
A. Herz, 3654 N. Paulina St., Chicago, Ill.....	Macolepidoptera	Germany (esp. Berlin region) United States (esp. Chicago region)	8,700	1,370	None	1	Yes[1]	No plans	Yes
H. C. Huckett, R. F. D. Calverton, Long Island, N. Y.	Muscidae and Anthomyiidae (Diptera)	North America and Scandinavia	16,000	800	2	30	Yes[1]	U. S. National Museum	Yes
Josef N. Knull, Forest Research Inst., Mont Alto, Pa.....	Coleoptera as follows: Cleridae, Corynetidae, Elateridae, Buprestidae, Cerambycidae, Scolytidae	N. America	25,000	1,881	35	37	Yes	No plans	Yes

Earl F. Krueger, 841 Montrose Ave., Chicago, Ill.....	Lepidoptera	World, esp. United States	10,000				Yes	No plans	
Lloyd M. Martin, P. O. Box 52, Roscoe, Calif.....	Lepidoptera	N. America	22,342	648	None	385	Yes	No plans	Yes
A. L. Melander, College of the City of New York, N. Y.....	Diptera	World	200,000	6,000	600		Yes		No
Warren C. Miller, 111 Ellenwood Ave., Bedford, Ohio.....	General	Ohio and Adirondack Mts.	4,000				Yes	No plans	No
William Procter, Bar Harbor, Me.....	General	Mt. Desert Is., Maine	5,500	2,000	None	1	Yes	Phila. Acad. Nat. Sci.	No
Oliver I. Snapp, Fort Valley, Ga....	Especially Coleoptera	Southern & Eastern U. S. & California and S. America	10,000	2,000			Yes	No plans	Rhyncho-phora
Geo. M. Stirrett, 90 Park St., Chatham, Ont., Canada.....	Halticinae (Coleoptera)		2,594	258	None	2	Yes	No plans	Yes
Alex. K. Wyatt, 6116 Forest Glen Ave., Chicago, Ill..	Lepidoptera	Boreal America	11,850	3,547	1	33	Yes[1]	No plans	Yes

[1]By appointment or with reservations.

REPORT OF THE COMMITTEE ON INSECT COLLECTIONS

A year ago your committee attempted to secure information on the private insect collections in the United States and Canada to supplement similar information on public museums secured by the Committee on Insect Collections of the Entomological Society of America. Since the publication of the results of our questionnaire in the February 1933 issue of the Journal, data on 16 additional collections have been obtained and are here given. (Pages 16 and 17.)

Persons possessing private collections not recorded in this report, or the report of 1932, should send complete data to some member of the Committee. Last year's report indicated Dr. H. W. Allen as working on the Tipulidae. The group in which he is interested is the Tiphiidae.

Respectfully submitted,

C. P. ALEXANDER
E. C. VAN DYKE
T. H. FRISON
H. M. HARRIS
J. J. DAVIS, *Chairman*

Upon motion regularly made and seconded, it was voted that the report be adopted.

REPORT OF THE COMMITTEE TO FORMULATE PLANS FOR INVESTIGATIONS OF THE CODLING MOTH FROM BIOLOGIC AND CONTROL STANDPOINTS

In the emergency resulting from the establishment of more stringent regulations regarding spray residues, the Codling Moth Committee has continued to serve as a clearing house, in order to aid in a better coordination of efforts to work out a solution of the problem. The chairman, through his official connection with the Bureau of Entomology, has participated in the compilation of research programs for the 1933 season, which were sent to all entomologists interested. At the close of the season, the various workers were invited to pool the season's results, in order that they might be made available more rapidly than is possible through the usual channels of publication. The response to this request was most gratifying, and the available information has been mimeographed and distributed to those interested.

In spite of unfavorable financial conditions, there has seemed to be a desire and a need for a general conference to consider future research work on the codling moth. The Committee is therefore taking steps to sponsor such a conference, and it is proposed to spend two or three days in a thorough study and discussion of all phases of the problem, in order that future research work may be well coordinated. After a consideration of several possible times and places, it has been decided that the best interests of the greatest number will be served by holding the conference at Lafayette, Indiana, the last two or three days in February, immediately preceding

the annual meeting of the North Central States Entomologists and of the Central Plant Board. Further details of this conference will be announced later.

Respectfully submitted,

B. A. PORTER,
Chairman of the Committee

Upon motion regularly made and seconded it was voted the report be adopted.

REPORT OF THE COMMITTEE ON RESEARCH WORK ON THE CONTROL OF THE EUROPEAN CORN BORER

For several years an extensive fall survey has been conducted in the one generation area by the Federal Bureau of Entomology in cooperation with the Bureau of Plant Quarantine and various state agencies to determine the annual changes in the European corn borer infestation. This survey covered portions of the infested territory in New York, Pennsylvania, Ohio, Michigan, and Indiana, but due to the reduction in funds and personnel, not only in the Bureau of Entomology but also in organizations which had heretofore aided the Bureau in conducting the surveys, the 1933 survey was necessarily greatly reduced in scope. Observations made in 1065 fields in 48 counties were as follows:

(1) The territory surveyed in the one-generation area showed a decrease in borer population as compared with data obtained in the same area in 1932.

(2) The borer population in surveyed counties in Indiana was approximately double that of 1932.

(3) The surveyed section of the state of Michigan, as a whole, showed a decided decrease, although the borer infestation in three counties remained unchanged.

(4) While Lucas County in Ohio, and several adjacent counties showed a rather decided increase due to favorable weather conditions, most of the other counties contained smaller borer populations than for 1932.

(5) The data obtained from the comparatively small number of counties surveyed indicate that the trend of borer population extends in a southwesterly direction.

(6) While two counties showed slight increase in New York, a general decrease apparently occurred in the state, based upon results secured in the comparatively small number of counties surveyed.

(7) Weather conditions in general were extremely unfavorable for egg deposition, but decidedly favorable for the establishment of larvae.

(8) In general, the corn crop was rather light in the territory surveyed, although in some localities where favorable weather conditions prevailed, excellent corn was produced.

(9) The districts in which corn borer increases occurred coincided very closely with the districts in which good corn was produced.

The situation in the Province of Ontario, Canada, was much the same as in 1932. Increases of populations in some counties were counterbalanced by decreases in others. For instance, there was an average increase of approximately 14 per cent in the two main husking corn counties, Essex and Kent, and an average decrease

in the adjoining counties of about 30 per cent. A severe drought prevailed over most of the Province during the greater part of the season, which appeared to shorten greatly the egg laying period, but did not interfere nearly so much as expected with the establishment of the young larvae.

The borer population in the Province of Quebec has continued to increase, but has not as yet to such a degree to cause appreciable damage.

The European corn borer laboratories at Sandusky, Ohio, and Monroe, Michigan, were combined with the Toledo Laboratory July 1, 1933, at a new location (1920 Parkwood Avenue). There was much curtailment of the work and, despite the changes which were made in the middle of the season, there was no serious interruption in the continuity of the experiments that were to be continued, due to the splendid organization. The work continued at the Toledo Laboratory and Farm included the following:

(1) Parasite introduction. The introduction of parasites from foreign countries was materially reduced, but the work of rearing and introducing parasites already in their possession, plus necessary parasite biological research, was continued as heretofore, although somewhat curtailed because of reduced funds.

(2) The corn variety tests in cooperation with agronomists, with special reference to tolerance and resistance under varying corn borer populations.

(3) Cooperative work with the agricultural engineers in developing plowing equipment and the corn combine, plus studies upon various cultural practices as applied to corn borer control.

(4) Insecticides. Testing on a field scale the materials which had given promise in previous years.

(5) Survey of the intensity of infestation.

The members of the committee who had an opportunity to inspect and study the work during 1933 were very favorably impressed with the fine set-up under the reduced appropriations, and worthwhile fundamental work in progress. The work had progressed with unusual success under especially unfavorable conditions as a result of absorbing drastic cuts and consolidating several laboratories in mid-season.

The committee desires to emphasize the fact that the corn borer investigations have been conducted over a sufficient period of time so that results can be better evaluated and better practical use be made of them than at any previous time. It should be emphasized that many of the results of the fundamental investigations have an immediate application in the betterment of agricultural practices other than corn borer control.

The research projects now in operation are highly important and should be continued.

There appears to be no unnecessary duplication in research work conducted by the Federal government and the States. The States are urged to continue their cooperation, not only in research, but also in intensity studies and in scouting work.

Respectfully submitted,

GEO. A. DEAN, *Chairman*
L. CAESAR
D. J. CAFFREY
T. J. HEADLEE
J. J. DAVIS

Upon motion regularly made and seconded, it was voted that the report be adopted.

PRESIDENT HINDS: Report of Committee on Training of Entomologists.

No report was presented.

REPORT OF THE SUB-COMMITTEE ON ENTOMOLOGICAL EXHIBITS FOR THE CHICAGO CENTURY OF PROGRESS EXPOSITION

As indicated in the last report of the Committee on Exhibits at the Chicago Century of Progress, it was impossible due to financial conditions for the management of the Chicago Century of Progress to carry out their original plans for entomological exhibits. A number of exhibits were used showing insect activities or using insect material. Dr. W. E. Hinds assembled an excellent exhibit on the boll weevil and this exhibit will be continued next year. Among the others may be mentioned the exhibit on termites, several exhibits including a part of the Federal exhibit on insects as carriers of disease organisms.

There was also an exhibit of South American butterflies and moths and a small exhibit of honey bees and bee products, the latter unit falling far short of the plans of the exhibit committee.

There were several other smaller insect exhibits. It is unfortunate that the plans of the committee could not be carried out but this was due to conditions and not to lack of work on the exhibit units.

C. L. METCALF
J. J. DAVIS
W. E. HINDS
W. H. LARRIMER
C. H. PARKS
J. S. HOUSER
E. O. ESSIG
W. P. FLINT, *Chairman*

By vote of the Association the report was accepted. In consideration of the fact that it was the present plan to continue the Exposition another year and that there was a possibility of more funds being available for 1934, the Association voted that this committee be continued for another year.

REPORT OF THE SPECIAL COMMITTEE ON POLICY OF THE JOURNAL OF ECONOMIC ENTOMOLOGY

In the absence of the Chairman, H. J. Quayle, A. F. Burgess, a member of the committee, called attention to the Questionnaire sent out to the members in the December Journal and stated that there had not been sufficient time to compile any of the results.

The report was accepted and attention was called to the recommendation of the Executive Committee that the incoming President continue this committee.

REPORT OF THE SPECIAL COMMITTEE ON JOINT MEETING WITH THE ENTOMOLOGICAL SOCIETY OF AMERICA IN CHICAGO

W. P. Flint, Chairman, moved that in view of the fact that this report would duplicate that already given in the report of the Secretary that report be accepted as covering the report of this Committee and that the Committee be discharged.

This motion was regularly voted upon and adopted by the Association.

REPORT OF THE SPECIAL COMMITTEE FOR INVESTIGATION OF REORGANIZATION OF ENTOMOLOGICAL RESEARCH IN THE FEDERAL GOVERNMENT

Last spring rumors and reports were circulated relative to reductions in federal appropriations which if made would result in serious curtailment of scientific work in the Department of Agriculture, and of projects for which allotments are made by the Department of Agriculture to the state agricultural experiment stations. It was also reported that extensive changes in organization were contemplated. Because of these conditions, President W. E. Hinds on May 14, 1933, appointed the undersigned Special Committee, consisting of members of the Association not connected with the federal services, to do what could be done on behalf of the Association to preserve and to sustain essential features of the entomological activities of the federal government, and to assist in saving the allotments of funds for entomological research in the state agricultural experiment stations.

A preliminary account of the activities of this Committee was read for the information of entomologists attending the joint meetings of the two entomological organizations in Chicago, and at that time (June 23), under the chairmanship of Vice-President C. H. Richardson, the Entomological Society of America voted to empower the same Special Committee to represent that organization also, it being likewise voted that whatever expenses were necessarily incurred by the Special Committee should thereafter be met by the two entomological organizations jointly. Since the report read at Chicago is not a matter of record, this final report covers all the activities of the Special Committee, and the report is prepared for presentation to both entomological organizations.

The Special Committee first met in Washington May 18. At that time no definite announcements had been made of exact plans either for reductions in appropriations or for reorganization. It was realized that in the absence of announcement of specific plans, the Committee must confine itself to statements of principles, but it seemed better to permit the officials to know that entomologists are interested in these problems before any irreparable damages might occur. At that time no exact idea of probable reductions could be formed, but in certain other scientific organizations of the federal government, drastic curtailments of personnel had been made prior to the appointment of the Special Committee. The Committee assumed that in principle members of the two entomological organizations favor reduction in government expenditures, and even that they might not oppose reduction in appropriations for entomological work under present economic conditions, provided that the important and vital phases of this work are maintained. The problem confronting ento-

mologists and others interested in the scientific activities of government is to see that the work is suitably organized and administered and supported in proportion to its importance but without extravagance.

The proposal to reorganize the work of the federal Department of Agriculture on a crop basis, a plan which has been brought forward sporadically but advocated persistently since 1898, was again being discussed. Entomologists are indebted to Dr. L. O. Howard for his unrelenting opposition to this plan, in so far as it was intended to apply to entomological work, from the time of the first proposal to the end of his term of office. It is impossible to estimate how much better the entomological work of the government now is than it might have been if this pernicious plan had been adopted when first proposed, but unquestionably the marvelous development of federal entomological work is in considerable degree due to administrative unity.

During last spring and early summer, there was a general feeling of uncertainty regarding the future of scientific work in government service which was destructive of morale. This unrest had its origin in statements made by the Director of the Budget in opposition to research in government service, in demands of certain powerful commercial organizations which oppose research at government expense and which also insist on simplification and reduction of governmental activities.

On the occasion of the first visit of the Special Committee to Washington, conferences were had with the Secretary of Agriculture, the Director of Scientific Work, the Chief and the Assistant Chief of the Bureau of Entomology, the Chief of the Bureau of Plant Quarantine and with various leaders in entomological work of the Department. Aside from an effort to learn everything possible of conditions, the Committee at that time confined its efforts to the presentation of the following letters:

(1) To the Secretary of Agriculture, urging that the entomological research be maintained as a single administrative unit, and that if eliminations of either personnel or of projects were deemed necessary, they be undertaken only after consultation with the Chief of the Bureau of Entomology and the division leaders concerned. In explanation of the first of these recommendations, the Committee wishes to state that, since it appeared probable that the significance of the name "bureau" might be changed, and since combinations of some nature seemed almost inevitable to satisfy demands arising from outside the government service, it did not seem expedient to insist too strongly on the retention of bureau rank for the entomological research, and the retention of unity of administration was deemed by the Committee to be vastly more important than the particular name applied to the research organization. The recommendation that informed men be consulted prior to action was based on the fear that enthusiasm for organization reforms might lead certain administrative officers to act on their own initiative, without such advice.

(2) To the Secretary of Agriculture, urging that funds for foreign quarantines maintained by the Bureau of Plant Quarantine be continued without appreciable reduction, and calling attention to the fact that any considerable reduction of funds for that Bureau could not be met by equal distribution of the reductions to all projects, since too great reductions would merely render domestic quarantines ineffective.

(3) To the Director of the Budget, pointing out the urgency of maintaining the federal entomological research, because of the heavy tax which insect depredations levy on agriculture, and urging that the integrity of the work be maintained.

(4) To the Director of the Budget, pointing out the fact that entomological investigations conducted in state agricultural experiment stations are often long-time projects, and that serious curtailment of funds for these stations would cause loss of valuable entomological data. The spray residue problem was cited as an emergency which necessitates vigorous investigations by agencies in the several states, and as a type of problem for which state workers must assist in finding a suitable answer. Since the Directors and workers of the agricultural experiment stations were by that time thoroughly and effectually organized in an effort to preserve the state allotments for station research, this Committee thought it best merely to endorse their efforts.

(5) To the Director of Scientific Work, repeating the recommendations made to the Secretary of Agriculture. Since it was known that Dr. C. L. Marlatt would retire from the chiefship of the Bureau of Entomology in the autumn, because of age limitations, and since in a period of such uncertainty vigorous leadership is more than ordinarily necessary, the Committee also advised that there be no delay in the appointment of the next Chief of the Bureau. We also pointed out to the Director the need of continuous cooperative effort between state and federal investigators, and suggested certain qualifications which should be possessed by the next Chief of the Bureau in order to foster a more complete spirit of cooperation.

Following this first visit to Washington, the Committee undertook to keep in touch with events there in so far as entomological work was concerned, and the Committee is indebted to many entomologists for help in this effort. In July there was reason to believe that no steps had been taken relative to the selection of the next Chief of the Bureau of Entomology, so Doctor Felt interviewed the Secretary of Agriculture and the Assistant Secretary on this point. At that time he also pointed out to these officials the dangers inherent in the organization of entomological research on a crop basis, which continued to be discussed, and the Secretary of Agriculture gave the Committee an opportunity to present its recommendations relative to reorganization. These were formulated and presented to the Secretary on September 14, and the following points were discussed:

(1) It was urged that entomological research be maintained as a single administrative unit, to prevent disruptive scattering of a homogeneous agency. Numerous instances were cited of important lines of investigation which cannot be divided on a crop or other production basis, such as taxonomic research, the Insect Pest Survey, physiological, morphological and toxicological investigations, biological control research and certain beneficial insects, and indicating that many injurious insects fail to restrict their work to single types of crops. The providing of library facilities and proper laboratory equipment would be extravagantly duplicated but the most important consideration is the need of technical administrative guidance for entomological investigations, which would rarely occur if the entomological work were located in crop production units. That emphasis on the dangers of disruption of the entomological research was not entirely groundless has been indicated recently by the fact that investigations in plant pathology in the Bureau of Plant Industry

have been further divided on a crop basis, and in such a manner as to threaten the efficiency of work in that field.

(2) In these recommendations the Committee also expressed the opinion that a reuniting of research and quarantines would not be beneficial to either branch of the entomological work, and cited the fact that in many states it has been found expedient to set up separate organizations for these two phases of entomological activity. The Committee stated that, while it doubted the possibility of affecting appreciable economies by such a combination, it did not wish to urge or to oppose any plan which would cause disorganization in the course of such changes within the Department which were deemed essential, aside from insistence that the entomological work should not be scattered. Since combinations of some sort seemed inevitable, in order to permit the administration at least to appear to conform with the demands of certain outside agencies which were demanding reorganization and to appear to be instituting measures of economy, the one vital point seemed to be to prevent disruptive changes and scattering.

The transfer of Mr. Lee A. Strong from the chiefship of the Bureau of Plant Quarantine to the chiefship of the Bureau of Entomology on October 1, presages a union of these two bureaus engaged in entomological activities. A more recent announcement indicates that still other control and eradication activities are to be placed in the combined Bureau. These actions also give cause to believe that for the present danger of a scattering of the entomological research into numerous organizations is averted. The Committee feels that, aside from whatever reductions in funds have already been made and which may hereafter be made, the entomological work is now at least safe from dangers of disruption.

During the past summer there was a considerable reduction in the funds available for entomological research. While the Committee cannot know the significance of all the changes which this reduction made necessary, it wishes to state that so far as we are advised, the reduction has been met in a fine spirit of cooperation, which has reduced the damages which any serious curtailment of funds must inevitably cause.

The Committee desires to state that it has not made recommendations relative to personnel or to details of administrative policies, but that rather it undertook only to recommend principles which would serve to safeguard and preserve the integrity of the work. The Committee has realized that it spoke for all active entomologists in the country, and that its recommendations must, in so far as possible, conform with the wishes of these persons.

It has been a privilege for the Committee to gain a closer contact with their fellow workers in government service. It is now our opportunity to assure our coworkers outside the federal service that we believe that the morale of the federal workers has been vastly improved in recent weeks, with the elimination of the dire uncertainties with which they were so long confronted, and we look forward expectantly and hopefully to increased activity in entomological work in the Department of Agriculture. We desire to express to the new Chief of the Bureau of Entomology our best wishes and our feeling of assurance that he will conduct the work in a spirit of cordial cooperation with all entomological workers and with justice and consideration for those workers under his administrative direction. We

desire also to express our satisfaction that the two national entomological organizations cooperated in this undertaking.

Respectfully submitted,

W. E. BRITTON
E. N. CORY
E. P. FELT
J. S. HOUSER
E. F. PHILLIPS, *Chairman*

Dr. Phillips as Chairman expressed his very sincere personal appreciation for the hearty cooperation on the part of the other members of the Committee.

This report was adopted by vote of the Association. President Hinds expressed the appreciation of the Association for the valuable service rendered and the committee was discharged.

President Hinds appointed the following:

Committee on Nominations: W. E. Britton, Chairman, L. S. McLaine and S. W. Bilsing.

Committee on Resolutions: R. L. Webster, Chairman, W. H. Brittain and J. J. Davis.

THE FIFTH PACIFIC SCIENCE CONGRESS

At the invitation of the Government of Canada and under the auspices of the National Research Council, the Pacific Science Association held the Fifth Pacific Science Congress in Victoria and Vancouver, B. C., Canada, June 1 to 14, 1933. Representatives and official delegates from some thirty countries bordering on the Pacific Ocean, interested in scientific research relating to that area, some 400 of the leading men of science in these countries, were in attendance. It was the first meeting of its kind to be held on the American side of the Pacific Ocean.

Although the attendance was somewhat smaller than at former congresses, the meeting was a success. The entertainment was excellent and the papers were quite good. There was plenty of time for discussion and what is equally as important, if not more so, there was much time for renewing old acquaintances and making new ones.

I was very glad indeed to again meet and chat with Dr. Tillyard. It was about six years ago that I first met Dr. Tillyard in Portland, Oregon, on his visit to our earwig parasite laboratory. Mr. Sweezy and Mr. Fulloway of Hawaii were present as also were a number of entomologists and parasitologists from the states. Dr. Tillyard gave a paper on weed control by insects and Mr. Sweezy one on biological control of insects in Hawaii. There were a number of other papers on biological control, several on insecticides, forest insects, citrus insects, grasshoppers, mosquitoes, ticks and tick borne diseases.

DON C. MOTE, *Official Delegate,*
Amer. Assoc. Economic Entomologists

FINAL BUSINESS SESSION

REPORT OF THE COMMITTEE ON RESOLUTIONS

A. BE IT RESOLVED, That this Association express through its Secretary an appreciation

1—To C. W. Collins, C. T. Brues and W. D. Whitcomb for their service in making the local arrangements which have been largely responsible for the success of this meeting.

2—To Mr. Appleton, function manager, and the Hotel Bradford, for the many courtesies extended and the excellent hotel arrangements.

3—To the local aides, Charles Clagg, L. J. Mille, and D. W. Farquhar, who rendered valuable assistance as ushers, lantern operators, etc., during the course of the meetings.

4—To E. J. Rowell, in charge of the New England Radio Market News, U. S. Department of Agriculture, Bureau of Agricultural Economics, who has given three broadcasting periods over WBZ, to give publicity to our meetings.

B. "The American Association of Economic Entomologists desires to place itself on record as approving of the many valuable research and other publications issued by federal, state and provincial governments of the United States and Canada, which have advanced the science of entomology, and its application to agriculture and allied industries, and would suggest that even under existing conditions immediate consideration be given by the agencies concerned for the printing of manuscripts, of key bulletins and other important results of research urgently needed for the use of economic workers in general.

In addition, the committee recommends that greetings and best wishes be forwarded from this meeting to Dr. L. O. Howard.

Respectfully submitted,

R. L. WEBSTER, *Chairman*
W. H. BRITTAIN
J. J. DAVIS

By vote of the Association, the report was adopted.

REPORT OF THE COMMITTEE ON MEMBERSHIP

PRESIDENT HINDS: "I might say that no member of the Committee was present. The preparation of the report was kindly taken in charge by Dr. DeLong. We want to thank Dr. DeLong for undertaking on very short notice a very considerable duty."

1. Recommendations for Associate Membership. 28 names.

Bobb, M. L.	Hussey, Priscilla B.	Nash, Robley W.
Bowen, Chas. Holbert	Hutchins, Ross	Pinckney, J. S.
Bradley, Wm. G.	Ito, Kiyoshi	Putman, Wm. L.
Burkholder, C. L.	Johnson, W. A.	Pyenson, Louis
Creighton, John T.	McPhail, M.	Rawlins, W. A.
Fife, Lorin C.	Menusan, Henry, Jr.	Sawyer, John F.
Garcia, Cirilo C.	Mezger, Erwin R.	Shaw, Frank R.
Gillespie, Arthur M.	Moore, J. B.	Stanton, Jas. W.
Gurney, Ashley B.	Musgrave, L. I.	Whang, Won Yill
Holmberg, O. E.		

2. Recommendations for advancement from Associate to Active Membership. 61 names.

Badertscher, A. E.
Balzer, A. I.
Bare, Clarence O.
Bartlett, K. A.
Benton, Curtis,
Boillot, B. F.
Brindley, T. A.
Brunson, M. H.
Bunn, Ralph
Clark, C. A.
Dawson, J. Carl
Deen, O. T.
Denny, Chas.
Dicke, F. F.
Dills, L. E.
Dobbins, T. N.
Donohoe, H. C.
Dorman, Russell
Douglas, W. A.
Farmer, L. J.
Fletcher, F. W.
French, Geo. T.
Good, N. E.
Harrison, P. K.
Hockenyos, Geo. L.
Hoyt, Avery S.
Jones, E. T.
Jones, E. W.
Jones, Geo. D.
Jones, L. J.
Keck, C. B.
Landis, B. J.
Lehman, R. S.
Lott, Earl
Mabee, W. B.
MacCreary, Donald
Mason, H. C.
McNeel, T. E.
Montgomery, B. E.
Morrill, Austin W., Jr.
Morton, F. A.
Newton, R. C.
O'Dell, J. H.
Parker, L. B.
Plummer, Chas. C.
Russell, E. E.
Schopp, Ralph
Sellers, W. F.
Shands, W. A.
Sheaffer, F. E.
Stage, H. H.
Stewart, M. A.
Stiles, C. F.
Stitt, L. L.
Stone, M. W.
Swingle, M. C.
Talbert, T. J.
Wilcoxon, F.
Wisecup, Clell B.
Woodworth, Chas. E.
Young, H. C.

3. Recommendations for election to Foreign Membership. 3 names.

Fredericks, Dr. Karl Soudek, Prof. Stepan Zander, Dr. Enoch

4. Recommendations for reinstatement. 3 names.

Borden, Arthur D. Dobroscky, Irene D. Glick, P. A.

5. Resignations. 3 Active and 8 Associate members.

Arnold, Thomas A.
Boyd, Mark F.
Riley, H. K.
Fattig, P. W.
Gibson, L. E.
Grant, Dudley H.
Horton, Harvey A.
McGough, James M.
Riddle, Hazel W.
Vanderford, H. T.
Wheeler, Andrew J.

6. The Committee recommended in the case of two members, who for financial reasons and because of ill health felt it necessary to resign, that in view of their long and distinguished service in Entomology and their attachment to this Association for so many years, the dues of these members be remitted and their names continued in our membership list.

7. In view of the unusual financial conditions, an extension of time be allowed those members whose dues are in arrears and who are consequently subject to be dropped on January 1, 1934. This extension to be allowed at the discretion of the Secretary and Membership Committee. Many of these men have just resumed work after varying periods without a position and have expressed the hope of continuing their membership.

8. That the replies to the questionnaire regarding classes of membership have been thus far of insufficient number to adequately express the opinion of the whole Association.

D. M. DeLong, *Chairman Pro-tem*

This report read by the Secretary in the absence of Dr. DeLong was acted upon item by item by the Association and then the report as a whole was by vote of the Association, accepted.

INFORMAL STATEMENT FOR SUB-COMMITTEE ON PUBLICITY

President Hinds appointed September 1, 1933, a committee on publicity, which he designated as a sub-committee of the special group charged with doing what might be possible to conserve the essential entomological activities of Federal and State agencies which might possibly be disturbed in connection with the somewhat extensive reorganization of the Federal Department of Agriculture.

The committee consists of Professors J. J. Davis, W. B. Herms, Dr. Wilmon Newell, Mr. Clay Lyle, Dr. E. N. Cory and the undersigned. It has been impossible to have a meeting of the committee. Correspondence developed the fact that in the more important entomological centers a reasonable degree of attention was given to publicity, and since the organization of the committee, the Federal Bureau of Entomology has placed responsibility for public relations with the Insect Pest Survey. Correspondence also developed the fact that feature writers were receptive to suggestions which might result in satisfactory copy. The difficulty in this respect has been to bring the source of information and the popular writer together. Ordinarily this must be done locally and has been brought about to a considerable extent.

The American Association for the Advancement of Science maintains a very efficient publicity agency, and it is urged that entomologists continue as heretofore, to submit informative and suggestive abstracts to this agency. Science Service should also be given the support of entomologists.

The publicity for the Boston meeting has been very satisfactory. One important feature, arranged by the Secretary and probably not generally known to the members, was the provision for three short broadcasts on the agricultural program of Station WBZ. These were given by President Hinds, Mr. Burgess and the undersigned. It is probable that more can be done along this line in connection with future meetings.

E. P. Felt

NOMINATION OF JOURNAL OFFICERS BY THE ADVISORY BOARD

For Editor—E. P. Felt.
Associate Editor—D. M. DeLong.
Business Manager—A. I. Bourne.

By vote of the Association this report was adopted and the above officers elected.

President Hinds: We adopt this report with a great many thanks to Dr. Felt for the very unselfish and extensive labor of love that he has given all these years to getting out the Journal. (Applause.)

REPORT OF THE COMMITTEE ON NOMINATIONS

Chairman, W. E. Britton—The work of this committee has not been an easy one, and there are several men who, from their long period of service

and the quality of their research work, are deserving of being elected President of this Association.

The Committee thought at this time a man from a state, who wishes to have the Association stand back of the protection of entomological research, might have a stronger influence in looking after such matters during the coming year and for that reason, the Committee has made its choice.

President: E. F. Phillips.
First Vice-President: F. C. Bishopp
Vice-Presidents: (Pacific Slope Branch)—G. I. Reeves.
(Cotton States Branch)—R. W. Leiby.
(Eastern Branch)—L. A. Stearns.
(Section of Plant Quarantine and Inspection)—A. S. Hoyt.
(Section of Apiculture)—W. H. Brittain.
(Section of Extension)—M. P. Jones.

STANDING COMMITTEES

Executive Committee for three years:
A. F. Burgess. Two years—W. E. Hinds

Committee on Nomenclature:
Entire committee reelected.

Councillor for the American Association for the Advancement of Science for three years: G. M. Bentley.

Trustee for Crop Protection Institute for three years:
J. J. Davis.

Representative on Council of Union of American Biological Societies:
C. R. Crosby reelected.

Committee to Formulate Plans for Investigation of the Codling Moth from Biologic and Control Standpoints for three years:
W. J. Schoene.
G. M. List.

Membership Committee for three years:
C. H. Richardson.

Advisory Board, Journal of Economic Entomology for three years:
F. L. Thomas.
H. C. Huckett.

Committee on Insect Collections:
C. P. Alexander for one year.
E. C. VanDyke for two years.
T. H. Frison for three years.

Committee on Research Work on the Control of the European Corn Borer for five years:
G. A. Dean.

Board of Trustees of Permanent Fund for three years:
P. J. Parrott.

W. E BRITTON, *Chairman*
L. S. MCLAINE
S. W. BILSING

Upon motion regularly made and seconded, it was voted to accept the report of the Nominating Committee.

The Secretary was instructed to cast one ballot for the list of nominations as read and those officers were duly elected.

Dr. Britton escorted President-elect Phillips to the Chair.

PRESIDENT HINDS: "Dr. Phillips, it gives us great pleasure to welcome you as incoming President, and to extend our wishes for a bigger and better and more prosperous administration."

PRESIDENT-ELECT PHILLIPS: "Thank you, sir. Gentlemen, the next order of business is Miscellaneous Business. There has been a request that Dr. Felt make certain explanations regarding the policies of the Journal."

DR. FELT: I am certain this is not the time for extended remarks. I have been requested to say something about the proposals regarding the Journal of Economic Entomology as published in the December issue. I regard these as an effort to learn the desires of the membership throughout the country.

I had a little correspondence with Professor Quayle earlier and he admits that in his judgment some of those proposals are probably impractical. He is desirous of getting the opinion of members throughout the country. He had no intention whatsoever, as I understand it, of making a conclusive report at this time. The Journal came out so late that it was not possible for him to get as full an expression of opinion in regard to these propositions as he desired.

The Journal is now a going concern. What you want depends a little upon your ideals for the future. It is doubtful whether we should make any very marked changes in the immediate future owing to present financial conditions and support.

The Journal is dependent as you probably know, upon its subscription list. If we change to a markedly technical publication as some have suggested, it is likely to mean a material reduction in the number of subscribers and, of course, a lessening of financial support. I would like to have you read carefully the proposals and also the brief comments which I made upon those proposals and published in the December issue.

Those comments were made for the guidance of our members; that is, to give them a little better idea of the actual conditions, and not to influence opinion either for or against any proposal, except as it may have a somewhat marked effect upon the development and prosperity of the Journal in the future.

In the case of proposition 1, respecting typography, as pointed out, that proposition was submitted about two years ago. The vote was fifty-fifty, and no change was made.

In the case of proposition 2, that we provide reprints for all authors, that would very likely cost $500 or more, and would mean reduction in the amount of printed matter.

In the case of proposition 3, in regard to allotments from general income to the permanent fund, none was made this year.

In regard to number 4, the increased length of the papers, we all would like that. If we were to adopt the suggestion which is made in respect to that, it would mean publishing pretty nearly 9,600 pages a year in order to make it possible to allot each man eight pages each year. I am afraid there would be difficulties.

Under number 4 there is also some data in respect to the number of papers published by members and non-members, and the number of members publishing more than once. We have here as we always have in organizations, men who are leaders, men who contribute vitally to the influence of the Association. They take part in the main association, in the sections, and in the branches. Were we to attempt to restrict a man to eight pages or to say he should have but one paper a year, it would mean probably a serious limitation upon what I consider extremely valuable activities.

In respect to the editorial policy, under 5, that practically means, as I understand it, a setting up of a more technical publication and doing away with the publishing of the proceedings. If we set up a more technical publication, in my judgment there will have to be either a very material reduction in the amount of matter published or a substantial increase in the subscription price. The choice is yours.

The proposition in respect to a larger editorial board means additional machinery, and while perhaps for a year or two it could be operated without additional cost, ultimately somebody has to carry the load. We have an Advisory Board of six. The editor has felt at liberty to consult with the members and refer to them problems, and I really am somewhat sorry to say in the earlier years he consulted, and almost invariably the reply was "Use your judgment."

There is another stumbling block and that is in regard to the monthly issue of the Journal. There seems to be a general feeling that if we could get a number out every month, it would insure more prompt publication. It would if we could keep up with the subject matter coming in, but when we are anywhere from five to seven months behind in our

publication, it does not make much difference whether an issue comes out a week or a month later.

More prompt publication, in my estimation, is to be secured by providing more abundant publication facilities, more funds, and some day that will come. The monthly issue would involve printing twelve covers instead of six and that is simply routine expense bringing no income. I doubt whether just at present it is advisable.

F. C. Bishopp proposed the following series of resolutions relative to the work now going forward under the auspices of the Civil Works Administration:

1—We are aware of the fact that a supreme effort is being made to put a large number of men to work under the President's policy of taking men off the dole and putting them into productive lines. It occurs to me that in the entomological field we have a number of very useful projects which might be handled in this way, which have not been given any consideration or at least are not official.

2—We find there are a large number of local projects springing up under the impetus given this move of putting men to work, which are being initiated and carried forward without any expert supervision. It occurs to me that there may be a great danger in that.

Therefore, if I am not out of order, Mr. President, I would like to present another resolution,

WHEREAS, Efforts are being exerted to find useful projects on which to utilize the unemployed throughout the country on emergency funds

Resolved, That the membership of the Association carefully consider and present to the Civil Works Administration or other federal emergency organization, such entomological projects as lend themselves to such treatment;

That the Association urge that local, county and state projects of an entomological nature be referred to appropriate state or federal entomological authorities for approval, and that arrangements be made to have such projects supervised by official entomological agencies.

Upon motion by Dr. Hinds duly seconded, it was voted to adopt these resolutions.

MR. ALBERT HARTZELL: I have a suggestion to make. I do not know whether it is in order or not. I will read it in order to save time: In view of the fact that recently several articles have appeared in the insecticide literature in which the authors fail to state the names of the compounds used, thereby making it impossible for other investigators to repeat their tests, it would seem to me that in the interest of science this practice should be discouraged. We would not report on the control

of an insect without naming the species, and similarly it is illogical to omit the names of the compounds used.

J. M. Ginsburg expressed the desire that the time allowance for the presentation of papers be extended to ten minutes to allow better opportunity for the presentation of data to support the conclusions offered by the author.

This was very largely incorporated in the following motion made by J. G. Sanders:

I move that the incoming president appoint on or before March 1st, a committee on programs consisting of three active members of this Association to serve one, two and three years, and thereafter for three years, to assist the President and Secretary with programs for our annual meetings.

This committee is to study our program problems, to invite suggestions from members, and to devise and arrange programs which will be more satisfactory to our membership and more attractive to visiting scientists.

Right along that line, I feel we are hurting very much the value of our program by limitation to five minutes. I note since we have adopted the five-minute limit we no longer have any three-minute papers as we formerly had. It seems unreasonable to assume that all subjects brought before this Association are of equal importance.

It is also unreasonable to assume that all members of this Association have problems of equal importance to bring before the Association. I believe that our program is being made uninteresting and is not nearly as attractive to visiting scientists as formerly because we have reduced the time limit to such a remarkable degree.

I think we have had a great many complaints about the program situation and that is in no way criticising our Secretary who has no power otherwise. However, I believe something should be done in the way of appointing a Program Committee to make a real, serious study of the problem.

MR. FELT: I have full sympathy with the purpose to be accomplished. We really need more time for individual papers. One of the difficulties is the purely mechanical one. There are so many papers submitted. The one criticism that I would have of that motion as at present made is that it delegates the work to a committee. The program must of necessity be made up by the Secretary and there is no other agency quite so

efficient in handling a program and I think Mr. Burgess would bear me out in that. I would much prefer to have that motion modified to instruct or suggest to the Secretary that he exercise his discretion and endeavor to bring about a larger allotment of time for some of the more important papers.

MR. SANDERS: I think Dr. Felt's idea is covered in the way that motion is stated there, that this committee is to study the problem and assist the President and Secretary in preparing the programs.

W. E. HINDS: May I say by way of explanation as to procedure at this session, that while we started out with reminding the membership of the five-minute limit, it soon appeared it would be possible for us to get through with the session as we are doing at this time without absolutely enforcing it. Therefore, I took the responsibility myself of allowing speakers to go on until they were finished.

I have kept the time on each man as he presented the paper today, and yesterday. The average time, I am quite sure, will run very close to ten minutes. Some have spoken over fifteen minutes. Some finished, a very small proportion, in the actual five-minute limit. We have given latitude, tried to allow time for discussion not as much perhaps as we might have wished for, but I think we are closing very close to the scheduled time.

The motion proposed by Mr. Sanders was put to a vote and carried.

J. J. DAVIS: I think we all realize certain advantages of having our meetings with the other sections of the American Association for the Advancement of Science. On the other hand, I think we all realize certain advantages of holding our meetings near our hotel headquarters. For that reason, I should like to make this motion—

Where satisfactory and adequate facilities for the meetings are available at the hotel headquarters or nearby, that the Secretary and the local committee be requested to plan for meetings at the hotel or at such place.

C. H. HADLEY: In connection with that subject and having had the experience of last year, I would simply offer this suggestion to the President, that he plan with the other Association on having a common committee to make those arrangements for both Associations. I think that will facilitate the interests of our two Associations and keep us out of possible trouble with the main Association. They do not seem to like the idea of these two Associations apparently going ahead and making their own arrangements.

PRESIDENT-ELECT PHILLIPS: It is customary for the two entomological organizations to have a common local committee.

T. J. HEADLEE: I don't know, Mr. Chairman, whether the membership is familiar with the point Mr. Hadley was raising. For four years now to my knowledge after the local committee had made its arrangements, the secretary's office of the A. A. A. S. informed the hotel men that that office was the determining and the distributing factor, and in two of those four years they got by with it. In the other two years they did not. They did not get by with it at Des Moines. They tried it at Des Moines. The only reason we had those accommodations at Des Moines was because Richardson and Drake were able to hold the hotel authorities to it. They did not get by with it at Atlantic City last year.

It is necessary to make the office of the Secretary of the A. A. A. S. understand that this society is going to have desirable accommodations. If you do not do that you will have the experience of having the meeting two miles or more away from your hotel in midwinter. Pittsburgh won't be so good under those conditions.

W. E. HINDS: I think possibly a little word of explanation is due in connection with the arrangements for this meeting. We had a joint committee representing the two Associations and they made arrangements for our meeting at the hotel headquarters which, I think, had ample accommodations for us, and which we realize now would have been quite comfortable.

The change to holding the meetings on the campus here was due to the expression of a very few of the Entomological Society of America in favor of meeting here on the Harvard campus. It seemed advisable to the local committee and to the Secretary to accede to that request, although I would say it was a very small proportion of the membership. As it turned out here, I think it would have been very much more satisfactory for us if we could have had all our meetings at the hotel as originally planned.

Professor Davis' motion was seconded, put to a vote and carried.

Upon motion by Dr. W. E. Britton, it was voted that the next annual meeting be held at the same time and place as the meeting of the American Association for the Advancement of Science.

Dr. W. E. Hinds expressed his sincere personal appreciation to all the officers and committees for their hearty cooperation and loyal support during his term as President.

President Phillips then declared the 46th Annual Meeting of the American Association of Economic Entomologists adjourned.

PRESIDENTIAL ADDRESS

SOME ACHIEVEMENTS IN ECONOMIC ENTOMOLOGY

By W. E. HINDS

In attempting to fulfill the duty of presenting a presidential address at this the 46th annual meeting of the American Association of Economic Entomologists, I have been impressed by the critical situation of our profession under the present financial conditions which have resulted in a very serious curtailment in entomological work during the past year or two and which threaten still further restrictions in funds, personnel and effective service for Entomology. I have felt impelled, therefore, to choose as the subject for our consideration today "Some Achievements in Economic Entomology."

Economic Entomology is a very young science, having reached its present development mainly within the past century. Our present accumulation of knowledge regarding the life of insects and their near relatives as they affect mankind indicates that the economic losses which they have inflicted in recent years in North America amount to more, rather than less, than $2,500,000,000.00 annually. The vital losses are harder to estimate but we know that they are very large in the aggregate. It is certain that the economic losses due to insects have been increasing rapidly in this country during the past fifty years and we have every reason to believe that much greater losses must be expected in the future. Is man engaged in a losing battle with these insect foes? Surely if man is ever to become dominant over this innumerable group of Arthropod enemies, he must redouble his efforts to know these enemies more fully and to find more efficient methods for checking their multiplication and for reducing their injurious effects. These foes, some of which are allied with disease-producing organisms, have unquestionably been responsible for more destruction of property and for more deaths than have been caused by all wars, floods, and famines in our human history.

Facing such a vast and vitally important problem, if man is to have anything of consequence to say or to do about the final outcome, then surely the intelligent, beneficent, protective service of Economic Entomology must be greatly increased. To accomplish this desirable development, the general public, and especially our legislative representatives, must be made more fully aware than they are at present that a great increase in applied entomology is a vital necessity for the increased comfort, health, longevity and prosperity of man, and that to stop these

enormous losses is an economic necessity fully justifying and requiring increased expenditures of public funds. In the educational field the teaching of interesting and important facts about insect life and activities should begin in elementary school grades, and continue on so that all students may be better prepared to appreciate the importance of the study of Entomology.

We can mention here only some of the most outstanding accomplishments. The field considered is primarily American, but some phases of discoveries and their results are world-wide in their application and significance. It is hoped that this brief survey of achievements may help to increase the appreciation for Entomology among the general public as well as among the members of this Association.

THE LITERATURE OF ENTOMOLOGY.—To my mind the first and greatest achievement made thus far consists in the accumulation of our recorded knowledge regarding the vast hoards of insect species, how they live, multiply, and spread, their direct and indirect effects upon the welfare of humanity and what man can do to mitigate the detrimental effects of those species which he finds to be seriously injurious to him.

Let us consider first the systematic literature developed in North America primarily. From the record as given by Banks up to 1910, and a recent estimate given by Miss Colcord, Librarian of the U. S. Bureau of Entomology, we may estimate approximately 10,000 systematic works published up to this time. This vast systematic literature is basic for all economic work.

In the special field of Economic Entomology references are decidedly scattering previous to the publication of Dr. T. W. Harris' pioneer book on Insects Injurious to Vegetation in Massachusetts, in 1841. In the eight parts of Henshaw and Banks Bibliography of American Economic Entomology, we find references to some 12,645 articles published up to the end of 1904. During the early days there was no medium available for the publication of scientific papers. Most of the articles were brief and of popular nature and were printed in farm journals and newspapers so that they might reach and help the largest possible number of farm people at a minimum of expense. The number of articles published by Walsh and Riley, independently and jointly, between 1860 and 1888 reaches the amazing number of 2418. This number of references is 20 per cent of the total listed in the Bibliography of American Economic Entomology to 1905.

Turning now to the Index of Economic Entomology covering the economic literature from 1905 to the issue of the fourth volume in 1929, we find more than 100,000 references in these four volumes and another

25,000 are now being prepared for the forthcoming fifth volume. It is very difficult to estimate closely the number of books, reports, bulletins, circulars and articles covered by this much larger number of "references." Thus, during approximately the past three-fourths of a century the literature of economic entomology amounts to around 150,000 references covering a vast number of injurious species and also the materials, methods and agricultural practices or other treatment for reducing their injuries. This literature, including both systematic and economic, constitutes our greatest achievement thus far in economic entomology in America and the influence and applicability of much of it is world-wide.

INSECT COLLECTIONS.—The beginning of insect collections doubtless antedates the first writings regarding insect life. Collections have developed quite largely through the interest of nature lovers and amateur entomologists. Collections are, I believe, second in importance only to the literature as a foundation for all entomological advancement. The development of insect collections in the United States and Canada is led by their respective National Collections. The National Museum Collection at Washington is one of the greatest insect collections in the world. According to the Annual Report for 1932, it contained then well over 4,000,000 specimens. It is especially rich in the matter of types which now number over 50,000. A recent estimate as to the total number of named species, as kindly given me by Mr. J. E. Graf, Associate Director, places this figure at approximately 170,000 species.

The Canadian National Collection of Insects at Ottawa is already outstanding with some 800,000 specimens, 30,000 determined species and nearly 4,000 types of North American insects. Beside these there are literally scores of institutional and private collections, many of which are very extensive and rich in type material. In the aggregate, these numerous smaller collections probably fully equal the large National Collections referred to in total numbers of specimens, named species, type material, etc. Such collections of insect forms constitute an achievement that is of fundamental importance to the advancement of the science in every phase.

THE TEACHING OF ENTOMOLOGY.—The establishment of Entomology as a distinct academic subject, separate from the general subjects of Biology and Zoology, is due originally to a small group of enthusiastic pioneer teachers who deserve our tribute of recognition for their achievements. It is probable that the first special lectures on the subject were given at Harvard between 1837 and 1842 by Dr. T. W. Harris who was Librarian at that institution but whose hobby was Entomology. In 1870, Louis Agassiz brought to Harvard Dr. Hermann Hagan, who gave some

lectures in Entomology, but I am not certain that they were regularly scheduled for academic credit. We know that C. H. Fernald did give regular courses in Entomology at the Maine State College as early as 1872 and that Professor J. H. Comstock was permitted by the Trustees to give some lectures on Entomology at Cornell in 1873, although he did not graduate until 1874. During this intervening period of sixty years Entomology has become a regularly scheduled subject in the curricula of most of our colleges and universities. The rapid development of teaching in Entomology—as well as in all other agricultural subjects—was due very largely to the passage of the Morrill Act of 1862 establishing the Land Grant Colleges. The extent of this development is indicated by the fact that at least thirty institutions are now offering Ph.D. work in Entomology.

The widespread influence of this teaching development is plainly shown by the growth in membership of this Association. Organized in 1889, with nine entomologists present and with twenty-two becoming charter members, we have today well over 1200 members. Even this number does not include nearly all of those who have received special training in Entomology fitting them to render a helpful service in this profession. It is said that more than 5000 students have studied Entomology under Prof. J. H. Comstock. We can only guess at the many thousands more who have studied the subject under hundreds of other teachers. Surely these large and steadily increasing numbers of students of Entomology must constitute a very important factor in the increase of popular appreciation of, and financial support for, Economic Entomology which has made possible many of the other achievements which we shall mention.

State Experiment Station Entomology.—The second national legislative act of fundamental importance to Entomology was the Hatch Act of 1887 establishing Federal aid for State Experiment Stations. Naturally in due time these stations became engaged in the intensive and increasingly scientific study of insect pests and their control. The Stations have furnished both funds for the prosecution of needed investigations and also a means of publication for most of the results thereof. In all state agricultural experiment stations in 1930, some 524 distinct entomological projects were under way, covering a large part of the most important insect pests attacking farm and garden crops and their products, orchard crops, forest and shade trees, domestic animals and man. In such investigational programs in the United States and Canada some 60 distinct state and provincial institutions and organizations are sharing, and about 300 workers were giving whole or part time in 1932. The scientific output of this large group of trained workers

is adding steadily and rapidly to the sum of our knowledge regarding insect problems and measures for insect control in all sections of North America. The rapid development of Economic Entomology as an integral and important part of the State Experiment Station System during the past 45 years is a most notable achievement.

FEDERAL ECONOMIC ENTOMOLOGY.—Almost coincident and parallel with the development of Entomology in the States came that under the federal authority. Beginning in a most inconspicuous and inauspicious way in 1853 with the appointment of Townend Glover under the old Patent Office, there was comparatively little real economic work done until 1878, when Glover retired and C. V. Riley succeeded him. L. O. Howard's appointment as Riley's assistant followed quickly and thenceforth the development was rapid. Howard succeeded Riley as Chief of the Division in 1893 and through the next 35 years built up in the Bureau of Entomology the largest and strongest single unit of research in Economic Entomology to be found anywhere in the world. It forms a powerful leading and cooperating unit in the world-wide development of entomological research. During recent years its normal annual budget has been in excess of $2,500,000.00. On March 1, 1930, the total classified personnel of the Bureau of Entomology numbered 515. The work was then operating under eleven (11) major divisions. Over 100 field laboratories were being operated in the United States and also a number in other countries. This federal organization is in itself another great achievement. Its work was described in considerable detail a few years ago by Dr. H. T. Fernald. A few of the most notable achievements of the Bureau must be given more particular mention later.

ENTOMOLOGICAL RESEARCH IN CANADA.— Entomological work in Canada is organized on a somewhat different basis from that in the United States. An excellent summary of Entomological Projects being conducted in Canada for 1933 has recently been issued. It shows for the cooperating services (including four Departments of Agriculture, five Universities and four Colleges) a total of some 230 projects under way. A summary of the progress made and a list of publications issued is given for each project. In 1932 the Dominion Entomologist, Mr. Arthur Gibson, reported a staff of 82 trained entomologists, with a total of some 200 workers including clerks, student assistants, et al. Sixteen permanent laboratories, 11 temporary field stations and 10 plant inspection stations were being maintained.

INSECT PEST SURVEYS.—This type of entomological record work has now reached its thirteenth year in the United States and somewhat less in Canada. The accumulation of records on all pest species is already

exceedingly valuable, and has helped many times in modifying recommendations for insect control and in preparing for more effective widespread campaigns for control of various pests when serious outbreaks were developing. In grasshopper outbreaks of 1932, this enabled a saving of over $2,000,000.00. The card records now on file at Washington number over 200,000, with 80 per cent of them relating to insects already in this country. These notes apply to over 30,000 species of plant and animal pests distributed among 11,000 genera. The Canadian records are less extensive but very valuable also.

THE MEXICAN COTTON BOLL WEEVIL AND THE EXTENSION SERVICE.—The third of our fundamental national legislative acts affecting Entomology in the United States came as a direct outgrowth of the fight which was being waged by the Bureau of Entomology for the control of the Mexican cotton boll weevil. This pest entering South Texas from Mexico in 1892 had spread within ten years into the major part of the cotton growing area of that state and threatened to continue its ravages throughout the balance of the commercial Cotton Belt. The Division of Entomology recognized the gravity of the situation and began a serious study of the problem of weevil control in the spring of 1901, when W. D. Hunter was placed in charge of the full investigation, and on July 1 of 1902 the speaker took charge of the laboratory work on the weevil. It very soon became evident that certain changes in cultural methods of producing cotton in weevil infested areas would help to reduce the multiplication of weevils and the damage inflicted by this new pest. The possibilities of damage were shown in a most startling manner by the existence at that time in Texas of areas of a thousand acres of cotton which did not produce enough bolls to justify picking it over. Cotton growers were conservative men and slow to change their century old methods at the behest of a group of "boys" who came from various states far outside of the cotton belt. In order to secure a test of the methods recommended, Hunter was obliged to enter into legal contracts to reimburse cooperating planters if the crop produced under his recommended methods did not equal fully that secured on the same areas previously by the old methods. An immense area was under contract in this way by the season of 1903. Thereafter Congress appropriated a small sum of money, and placed Dr. Seaman A. Knapp in charge, to establish a Farm Demonstration Service which should take the best, proven results of scientific research to the farmers and show them just how it would help them to adopt these practices. This movement grew rapidly and spread through the Cotton Belt during the next ten years, outstripping the advance of the boll weevil. The practical value of the

results of this widespread demonstration method in applying entomological and agricultural recommendations proved to be so great that the Farm Agent, or County Agricultural Advisor, movement spread rapidly to all parts of the country and in 1914, through the enactment of the Smith-Lever Act, Congress established the Extension Service as a third branch of our national agricultural policy coordinate with research and teaching. Who can measure the economic returns from this indirect achievement as an outgrowth of our efforts at boll weevil control? There are now about 40 entomologists giving whole or part time as Extension Specialists in carrying entomological information to the farmers.

The boll weevil has often been called the "Billion Dollar Beetle", and it deserves the appellation. It has been estimated to cause an average loss in the value of the cotton crop of $200,000,000.00 per annum. The average potential damage where no control measures are used has been found to be between 35 and 40 per cent of the normal yielding capacity. Where improved cultural methods are used — without insecticidal measures—the damage is reduced to about 20 per cent, and where insecticidal control is also used properly, full crops are secured with but little weevil loss. It is conservative to estimate a saving of over $100,000,000.00 per annum in the cotton crop through the use of improved methods of cotton production and weevil control. The fight against the boll weevil has assured an abundant supply of cotton at a reasonable price to consumers. This is a direct achievement that is now saving at least $1.00 per person in the United States in the average annual cost of cotton goods which they must use. The influence of this saving extends around the world.

Insecticidal Materials, Methods, and Machinery.—The status of these elements in insect control was shown very fully in the exhibit made by the U. S. Division of Entomology at the World's Columbian Exposition in Chicago in 1893. At that time Paris green, kerosene emulsion, soaps, resin washes, tobacco dusts and pyrethrum, with carbon disulphide and hydrocyanic acid gas, were the principal insecticidal materials used. Bordeaux mixture and Paris green constituted about the only mixture for combating plant diseases and leaf eating insects in one combined treatment. Hand syringes, knapsack, bucket and barrel pumps represented the entire range in spray equipment then available.

Since 1893, the development of lead arsenate, as a result of deliberate research in the course of Gipsy Moth Investigations, constituted a notable advance in the insecticide field and for forty years this material

has held first place among arsenicals applied for the control of leaf-eating insects. Later came the development of calcium arsenate as a cheap insecticidal dust for control of the boll weevil; fluorine compounds; lime-sulfur solution for control of scales and fungi; engine oil emulsions of various types for the control of scales; white flies, etc.; standardized nicotine and pyrethrum extracts; derris dust and rotenone extracted from various sources; new materials for fumigants and a variety of ways of applying some of the old fumigants. A complete catalog of such materials would be far too long for mention here.

The development since 1893 in pumps, hose, nozzles and spray guns has given us power outfits ranging up to a size and capacity capable of covering orchards with a rapidity and thoroughness undreamed of previously. The largest forest, park and shade trees may now be protected and are being treated effectively on a vast scale preventing losses which, if allowed to occur, would be enormous. The development of aviation has brought into the field within the past ten years the insecticide dusting airplane. The enormous covering capacity of these machines and their practical economic value in numerous problems of insect control have been abundantly demonstrated, especially in the control of various forest insects, the cotton boll weevil, cotton leaf worms, grasshopper outbreaks, etc. An airplane can poison an acre of cotton thoroughly in less than two seconds. Cotton dusting airplane equipment transferred from Louisiana to Peru proved that for the control of cotton leaf worms one dusting airplane did more, and far better, work than did 4000 laborers applying lead arsenate spray by means of knapsack pumps and that two applications of calcium arsenate dust from the planes controlled these leaf worms very effectively through the season, while three applications of lead arsenate spray were decidedly ineffective in checking their multiplication.

Thus throughout the whole range of insecticidal materials, methods and machinery for insecticide application, we find another great field of entomological achievement, making possible more timely, economical and effective control of a large part of our most serious insect and fungous pests.

Biological Control of Insects.—With the marked increase in the number of insect pests imported into this country, it was but natural that there should follow a determined effort to bring in many of their parasites and predators to help in bringing these pests under natural control in their new environment. It is estimated that approximately three-fourths of our most serious pests are imported. Certainly more than 80 per cent of all of our insect control effort in America today is directed

against such imported species. Under our continental conditions, especially east of the Rocky mountains, the introduction of parasites and predators has failed to show as strikingly effective control of host species as has been achieved in numbers of cases in the Hawaiian Islands and by the Australian lady bird on Cottony cushion scale in California and at many points in the South. Still it is certain that substantial progress has been made. In the case of the Gipsy moth, millions of parasites have been brought in and some 20 species, at least, are known to have become established in this country. For the European corn borer, introduced about 1908, many millions of parasites representing 20 or more species have been liberated and field recoveries show that at least 12 species have become established.

While it is generally considered to be impossible to increase by artificial manipulation the usefulness of a native parasite in its normal habitat, it has been demonstrated to the satisfaction of many that in some cases this may be done. In Louisiana the cosmopolitan egg parasite, *Trichogramma minutum* Riley, is the most important natural enemy of the sugar cane moth borer, *Diatraea saccharalis*, which was brought into Louisiana nearly one hundred years ago. Through the experimental work of seven seasons in Louisiana, it has been proven that the usefulness of this native egg parasite in the control of the cane borer has invariably been very greatly increased with this particular pest. In 1932, the average yield of sugar was increased by nearly 1000 lbs. per acre in artificially colonized fields. Similarly beneficial results have been secured repeatedly also in Barbados and in Peru.

Numerous other cases of beneficial results in the field of biological control might be cited. California has been particularly successful in the importation of beneficial predators against various species of mealy bugs. The first of these was the Australian lady bird (Vedalia), which was amazingly effective against the fluted scale. The latest success is a very effective parasite of the citrophilus mealy bug. The development of the County Insectary system in California for propagating and distributing such beneficial insects has been one of the notable features of the Biological Control Achievement. Millions of dollars are being saved annually in the United States and Canada by all of this biological control work. This phase of economic entomology has been well worth while and seems destined to command more effort and to produce yet more valuable results in our future entomological practice. The placing of such parasite importation, multiplication and field colonization work upon a sound, safe, economical and efficient basis is a distinct achievement to the credit of American entomology.

MOSQUITO CONTROL.—These foes to the comfort and health of man and domestic animals are tremendously important. The problem of control is particularly serious and difficult in coastal marsh areas and near thereto. The New Jersey mosquitoes were among the first to achieve national notoriety and thus to provoke control efforts on a large scale. Accomplishments, in that state and in many other areas, show clearly that vast areas of land may be recovered to valuable use, population and land values increased and agriculture, health and comfort promoted through mosquito control campaigns. Inland communities are also awakening to the importance of such control work. Through persistent efforts Havana, Cuba, is a practically mosquito-free city and the Panama Canal Zone is transformed from a white man's graveyard to a desirable health resort.

CATTLE TICK CONTROL.—It was only 40 years ago that Smith, Kilborn and Curtice of the U. S. D. A. published the report of their epochal investigations which proved that Texas fever in cattle is transmitted solely by cattle ticks, and that extermination of cattle ticks meant complete elimination of the tick fever disease. In 1906, when the elimination of ticks was undertaken, under the leadership of the U. S. Bureau of Animal Industry, it was found that fifteen states were infested, ranging from Virginia to California, and as far north as Kentucky. In this vast area covering nearly 730,000 square miles, were 985 counties which had to be included under quarantine. Federal, state and county authorities have cooperated through this long struggle. Gradually and steadily the limits of tick infestation have been pushed inward and cleaned areas released from quarantine. At present about 90 per cent of the originally infested area has been cleared and released. Infestation remains in only parts of three states: Florida, Louisiana and Texas. The federal Civil Works Administration has recently allotted $2,000,000.00 to aid in the completion of the tick eradication program for 1934. In a few more years we may find the South completely freed from the burden of cattle ticks with consequent avoidance of losses which in 1906 were estimated as high as $130,000,000.00 a year. The increased meat and dairy products, improved soil fertility, etc., will be of immeasurable value to the entire nation.

BEEKEEPING.—The development of beekeeping in the United States and Canada has produced an industry of great direct value in the items of honey, wax, queens and package bees. The best estimates indicate that there are somewhere around 6,000,000 colonies of bees in the United States. It has been proven that bees are of great value also in the pollination of orchard fruits, clovers, and other valuable crops. The value

of their indirect service in producing crops of fruits and seeds is beyond estimation.

MEDICAL ENTOMOLOGY.—Here we enter a field in which every important scientific discovery may be of world-wide significance. It is an exceedingly complex and difficult field requiring the united efforts of medical doctors and entomologists. Credit belongs to the medical men for their original discoveries but entomologists and sanitarians have had a large part, and ultimately must take a still larger part, in the final work required to control—and perhaps completely exterminate—some important human diseases. Only a few of the most outstanding achievements in this exceedingly interesting and important field can be mentioned. Probably the progress made in the past 40 years may be shown most emphatically by making a series of comparisons.

Let us consider first what has been one of the most dreaded scourges of mankind—plague or black death—which, in the middle of the 14th century is believed to have killed one-fourth of the total population of Europe. For centuries it has spread terror in helpless affected areas. What would have been its toll and what the outcome of the unprecedented congregation of humanity into small areas during the World War, had not the means of spread and methods for control of plague been discovered previously! As it was, with plague, and also with typhoid, and malaria, these diseases were quite minor factors in the mortality records of that great conflict. Yellow fever is a fourth disease of special world significance. Endemic in Cuba for at least 150 years, it was an annual threat to our Gulf Coast port cities especially. In New Orleans alone, counting only the deaths in nine outstanding epidemics occurring between 1847 and including the last one in 1905, nearly 30,000 lost their lives. Today yellow fever has been wiped out in Cuba, Panama, along the west coast of South America and in many other areas. Only three endemic centers are left. What a blessing to mankind has been the decrease in this scourge. Never again, we believe, will there occur another widespread fatal epidemic of yellow fever. Had it not been for the ability to eliminate yellow fever, the building of the Panama Canal and the vastly increased transportation through that area would undoubtedly have served to spread yellow fever far and wide in tropical and subtropical areas where the yellow fever mosquito occurs. The Canal is made a blessing instead of a curse to mankind because of the fundamentally greater achievement of entomologists, sanitarians and medical men in the complete freeing from yellow fever of Cuba, the Canal Zone and other port areas of South America.

In our U. S. Army camps during and following the Spanish American War in 1899–1900, Typhoid fever spread largely by houseflies caused thousands of cases and took a much greater toll in lives than all other causes of mortality combined. Soon after this, anti-typhoid vaccines, sanitation, and fly control measures were found which applied generally by all nations during the World War reduced Typhoid to an almost negligible item in the total mortality from that four years of terrible conflict.

The solution of Malaria problems required some seventeen years of intense study from the time the causative organism was discovered in 1880 to the demonstration by Ross in 1897 of the exclusive role played by Anopheline Mosquitoes in its transmission from man to man. This discovery gave a tremendous impetus to the study of Medical Entomology. Almost immediately came announcements that ticks spread Rocky Mountain spotted fever in Montana, that head and body lice spread typhus fever, that the tsetse flies spread sleeping sickness in Africa, that fleas spread Bubonic plague from rats to man, etc., etc. Surely it is a fight to the death between these myriads of insects and alarmed, intelligent and determined man. Wonderful progress has been made within the past 35 years.

PLANT QUARANTINE.—The organization and development of a National Plant Quarantine Service is an exceedingly important achievement. State quarantines began slightly over fifty years ago. California led the way with its first state enactment in 1881 to provide protection against the introduction of the grape phylloxera. The effort to stop the spread of the gipsy moth led Massachusetts into action.

The spread of the San Jose scale in the eastern section of the country led to the general provision for Nursery Inspection and for quarantine measures against this scale and other dangerous pests. The Ohio Horticultural Society took the initiative in calling together a "National Convention for the suppression of insect pests and plant diseases by legislation." The meeting was held in Washington, D. C. in 1897 and a bill was drafted. However, Congress took no action and it required rather persistent educational work through fifteen years, led principally by Dr. C. L. Marlatt, before Congress enacted the federal Plant Quarantine Act in 1912. Immediately the Federal Horticultural Board was appointed by the Secretary of Agriculture with Dr. Marlatt as Chairman. Dr. Marlatt's service in bringing about this enactment and as Chairman and leader in plant quarantine work for the next 17 years constitutes an outstanding personal achievement of which all Americans may be proud.

It was an enormous task from the start to undertake practically all of the foreign and domestic federal quarantine regulatory and control work on plant pests. Fortunately this organization was ready to meet various emergencies as they occurred. Numbers of the most notable entomological achievements of the last twenty years have been accomplished through the direct action and with the invaluable cooperation of this quarantine organization.

THE GIPSY MOTH CAMPAIGN.—We are holding this meeting within a few miles of the area where the great fight against the gipsy moth began. This destructive woodland species occurring in Europe, Northern Africa and Japan, was introduced at Medford in 1869 by a Frenchman interested in the improvement of the silk industry in this country. Unfortunately some of his moths escaped from confinement to the woodlands where they multiplied slowly during the next twenty years. By 1889 their numbers had become enormous. They stripped the trees and over-ran the streets and homes. In 1890 the Massachusetts Legislature made the first appropriation for the control or eradication of this new pest. Professor C. H. Fernald of the Massachusetts Agricultural College and Experiment Station was made consulting entomologist and guided the work along sound lines. Naturally a number of Fernald's best trained students in Entomology became engaged in the work which thus had a very important reaction upon the character of teaching in entomology and also served to interest students in economic entomology as a profession. The fight against the gipsy moth was so well waged that the pest was held within the area of less than 400 square miles, for the next ten years and moths became so scarce that they were rarely seen. Extermination seemed almost accomplished. Then politics entered the field, the state appropriation was withheld, the work stopped for five years, and the moths multiplied so rapidly that an area of fully 4000 square miles became infested.

The annual damage to forests, shade trees and orchards then far exceeded the $1,250,000.00 which Prof. Fernald had estimated in 1898 as being the total amount likely to be required to accomplish complete extermination. But in the ten-fold larger area infested by 1905 extermination was considered to be impossible. The federal government gave aid from this time on, in cooperation with state activities. The project for control of the gipsy moth has become the largest undertaking against a single insect species ever attempted by man.

Since 1906 the Federal Department of Agriculture and the New England States in which infestation exists have waged continuous warfare on this pest. In spite of all these efforts, local spread continued until

1923, when a barrier zone was set up within which intensive scouting and cleanup work was carried on. This zone ranges from 25 to 30 miles in width and extends from the Canadian border to Long Island Sound, embracing about 9,000 square miles. Since that time the westward spread has been checked and certain serious infestations occurring outside of the main area have been exterminated.

In New Jersey an isolated infestation covering more than 400 square miles has been cleaned up through ten years of effort in cooperation with that state. This was a slow and laborious undertaking but the results accomplished have been very satisfactory. In August 1932, another severe infestation outside the New England area was found near Pittston, Pennsylvania. Investigations made thus far indicate a very serious situation here. More than 300 square miles have been found infested and it is probable that the insect will be discovered over a considerably larger area. Vigorous treatment is being applied to clean up this infestation also.

We should mention at least three items among the many very valuable beneficial results accomplished through the gipsy moth control work:

(1) The introduction of enormous numbers of parasites and predators upon the gipsy and brown-tail moths. Millions of these insects brought in from other countries have now established more than 20 new beneficial species which are helping in the natural control of both of these species and many other caterpillar pests as well.

(2) Arsenate of lead was developed as an insecticide for gipsy moth control and has become our most widely used arsenical poison.

(3) The greatest improvements in spraying machinery have been developed in this work.

The total expenditure to date has been some $25,000,000.00 but the results amply justify the effort. Dr. E. P. Felt stated a few years ago that if the gipsy moth were spread over New York state as over Massachusetts, the cost in New York for similar repressive work would amount to more than $5,000,000.00 annually. New York and other states have been well-protected during the past ten years by the "barrier zone" which has been so effectively maintained. Surely the prevention of spread of the gipsy moth and the extermination of isolated colonies occurring outside the area of general infestation constitutes one of our most outstanding achievements in applied entomology.

PINK BOLL WORM ERADICATIONS.—It was fortunate indeed for the entire Cotton Belt that the Federal Horticultural Board was in active operation and represented in Texas by a member, W. D. Hunter, when a wide-spread infestation of the pink boll worm was discovered in

Eastern Texas in 1917 and in Western Louisiana in 1918. The pink boll worm stands next to the boll weevil as a destructive pest to cotton and where both occur the damage done by one is practically added to that done by the other. Such a burden would eliminate the United States from its dominant position in the production of cotton. Complete eradication of these infestations was accomplished by the most painstaking cleaning up and burning of all cotton stalks, fallen bolls, lint and seed in infested fields. Every shipment of seed from infested areas was traced. Widespread scouting was continued for several years. Non-cotton zones were maintained for two or three years and by the strict regulation of adjacent areas and the heat-disinfestation of seed, compressing of lint, etc., these and other later infestations found in Central Texas were finally completely eradicated.

Pink boll worm infestations still exist in West Texas, New Mexico and Arizona not far from the border of Mexico. No complete cleanup of these areas is worth while until the certainty of prompt reinfestation from Mexican sources can be removed by the extermination of the pest in that country also. Recently pink boll worm infestations have been found in southern Florida and as far north as the southern edge of Georgia. This situation is being dealt with in a manner that gives protection to still more important cotton growing areas.

MEDITERRANEAN FRUIT FLY.—The discovery in April, 1929, that this much dreaded pest had become established in the heart of the Florida citrus area, spread alarm to the entire southern portion of the United States. It seemed a dark outlook indeed for the Florida citrus and vegetable industries. Much credit belongs to the Florida state authorities for their prompt, extensive and effective work and to Congress for so promptly making available the large appropriation required. Never before had so extensive and thorough control been put into effect so quickly as was true in this work. A large, trained force of Bureau of Plant Quarantine inspectors very quickly outlined the infested area and the destruction of infested fruit, the spraying of trees with poisoned bait for the adult flies, and other control measures went forward with amazing speed and efficiency. Within three months after discovery the extensive infestation which involved about 75 per cent of the citrus area of the state, was practically stamped out. Only three very small infestations were found thereafter and the whole undertaking was a complete success. The accomplishment of this eradication effort within a single year constitutes one of the most outstanding achievements of applied entomology anywhere in the world.

MEXICAN FRUIT WORM.—A close relative of the Mediterranean fruit fly, the Mexican fruit worm, has repeatedly spread from Mexico into the citrus orchards of the Rio Grande Valley. By prompt and thorough action these invasions have been stamped out and the citrus industry thereby protected. The enforcement of a host-free period has met with the hearty compliance of growers. Some 40,000 alternate host fruit trees have been destroyed during five years of work. This has greatly increased the protection for the 7,000,000 citrus trees growing in this valley.

FOREIGN QUARANTINES.—It is utterly impossible to estimate the value of the protection which has been rendered to the people of North America by the quarantines enforced and the port and border inspections maintained during the past twenty-one years by the U. S. Bureau of Plant Quarantine and by its Canadian counterpart. Literally thousands of interceptions of dangerous pests have been made. The Bureau of Plant Quarantine reported for 1931 the interception of 16,534 cases of dangerous insects and plant diseases. Increase in commerce, travel, airplane use, etc., add to the dangers of new importations. The very small number of new species introduced or established during this period shows very conclusively the economic value of this part of the work of our respective governments in the field of applied entomology.

CONCLUSION.—This review of entomological achievements is very incomplete. It has been necessary to omit many items which are possibly as noteworthy as some of those which I have chosen for mention. If by this imperfect statement, we may in some measure increase the appreciation felt, both by professional entomologists and by the public generally, for the science and practice of Economic Entomology as a fundamental necessity for human welfare, a wise and profitable expenditure of public funds, a happy field of investigational adventure and of satisfactory helpful service to our fellowmen, then this effort to review some of the outstanding Achievements in Economic Entomology will not be without value.

Papers read Thursday Afternoon, December 28, 1933

WHAT SHALL BE THE OBJECTIVE IN THE TRAINING OF AN ENTOMOLOGIST?

By DWIGHT M. DELONG, *Columbus, Ohio*

At the annual meeting of this Association three years ago, a committee appointed some three years previously gave a report upon the training of an entomologist. This committee set up at that time certain fundamentals regarding phases of training and conditions surrounding the same. As one who is interested in and engaged chiefly in the training of entomologists, the writer desires to bring forward at this time some further problems regarding type and emphasis of training and suggest certain objectives that seem desirable.

DIFFERENT POINTS OF VIEW.—Two different schools exist at the present time in point of view regarding training in entomology. Most colleges and universities, especially agricultural colleges, offer only undergraduate work in entomology and very few encourage the pursuit of graduate training. Most of these schools offer a series of undergraduate courses with the specific objective of giving the student information or factual material without including methods or technique in the studies of fundamental problems. This objective is evident even in some schools that offer graduate training. The training is highly encyclopedic and with a large amount of memorizing of scientific names and similar technical impedimenta. The finishing off course in the senior year is a thorough coaching with question material selected from previous civil service examinations so that the student may successfully pass the Junior Entomologist examination. The ultimate objective of such training is the examination grade and the "job" and after obtaining the appointment the goal is reached and the character of "research" is a minor problem. Frequently the training of the student is not especially adapted to development for research capacity and he has not been taught to see that his appointment is an opportunity to use training for productive work. It may be that his initial duties are largly routine but he will be expected to develop into a research man as he gains experience. Can he do this without broad training in the fundamental sciences? This type of training has been encouraged by the kind of examinations and other requirements stipulated by the U. S. Civil Service Commission and incidentally the largest number of men on certain registers are usually from those schools.

The other point of view followed by a small group of universities is to train the student for making the largest contribution through research. This is accomplished by giving the student a broad training in the fundamental scientific fields and thus establishing a sane basis for building and thinking. Civil Service examination questions are not even discussed with the student and he does not expect to be recommended for a position when he receives a bachelor's degree for he has just laid the foundation upon which to work. Although he might develop into a research worker if placed under proper direction in the right laboratory, he will probably develop much faster and better if guided for one or two additional years in his thinking in terms of scientific problems and principles. The object of such training is grounding in fundamentals, the formation of a basis for and the accomplishment of productive thinking—the using of factual material as a means and not as an end in itself. Such a man you may place in a research position on a problem concerning which nothing is known and he will be able to work his way out.

The former type of training also tends to encourage a standardized type of curriculum or training and to turn out entomologists in the same manner that automobile fenders are made, each having the same characteristics as every other one. On the other hand training should be an individual problem and be determined largely on the basis of individual ability, interest and the field of entomology for which he is best fitted.

The question of training is largely a matter of whether a man is to be trained in such a way as to become a "stuffed mammal" and fill a position in the "museum of the entomological world" or whether he is to become a part of an active laboratory force where only those are found who are able to do productive thinking and perform research.

The most difficult problem that confronts a teacher at the present time is to get a student to think. As a rule he will memorize, cram, read volumes of literature and write extended reports but he refuses to think. The research type of mind can usually be selected most easily by giving an examination which does not call for factual material as such but merely as a basis for thinking through a problem. Also quantities of research data or similar material may often be given the student for his interpretation. Such training is valuable if he is to learn to think.

One of the discouraging situations at the present day is that men trained without the research viewpoint are frequently placed in charge of research laboratories or research projects. In such positions they do not welcome young research workers who see new angles to the problem and who offer suggestions and they also frequently impede the work of other research workers who are associated with them or placed under their direction.

DIVISIONS, SEQUENCE AND SCOPE OF TRAINING.—The training that an entomologist receives might be divided into three phases or parts.

1. Training for scientific grounding and technical research.
2. Training for evaluating and presenting research data.
3. Training for professional and human contacts.

An accompaning chart (Fig. 1) attempts to show some of the most important subjects which the writer feels a student should have and some phases of their interrelation. Certainly the fundamental sciences as placed at the bottom of this chart are necessary as a basis upon which to build. It is difficult to show in this scheme the relationship of mathematics as it forms a fundamental basis for chemistry and physics and also is important in the biological sciences and in the interpretation of data. It therefore is a fundamental consideration in at least two phases of this outline. Foreign language also is important in the interpretation of research as well as being of a cultural nature. Other fundamental articulations or connections existing between two or more of these subjects frequently cannot be shown on the chart because of complications in connecting lines. Regardless of the field of entomology in which a man is going to major he should have training in these fundamental sciences. The amount of work needed in advanced courses in these scientific fields, however, will depend upon the special field of his major. No one should enter the biological field at present who does not have a fundamental background of both plant and animal physiology and at least the fundamentals of biologic chemistry. These are basic for the understanding of the principles and processes of life. Since a vast majority of insects are feeding upon living plants, the research worker will never be able to explain certain insect reactions or account for certain insect activities unless he is able to understand, measure and correlate changing processes in the plant with his studies of insects. As a rule a research worker is more greatly handicapped by problems arising in related scientific fields than those which pertain to his own.

The fundamentals of entomological training are important also but the "57 varieties" of courses are not essential to the production of a good research man. Basic courses stressing fundamentals should be considered in this as well as other scientific fields.

The instructor is responsible for certain attitudes toward or impressions formed concerning almost any field of work. The proper presentation should open the field to the student rather than leave the impression that it is a closed science. If properly presented more unsolved problems can be discussed or called to the student's attention in a very short time than he can answer during the remainder of his life by continuous re-

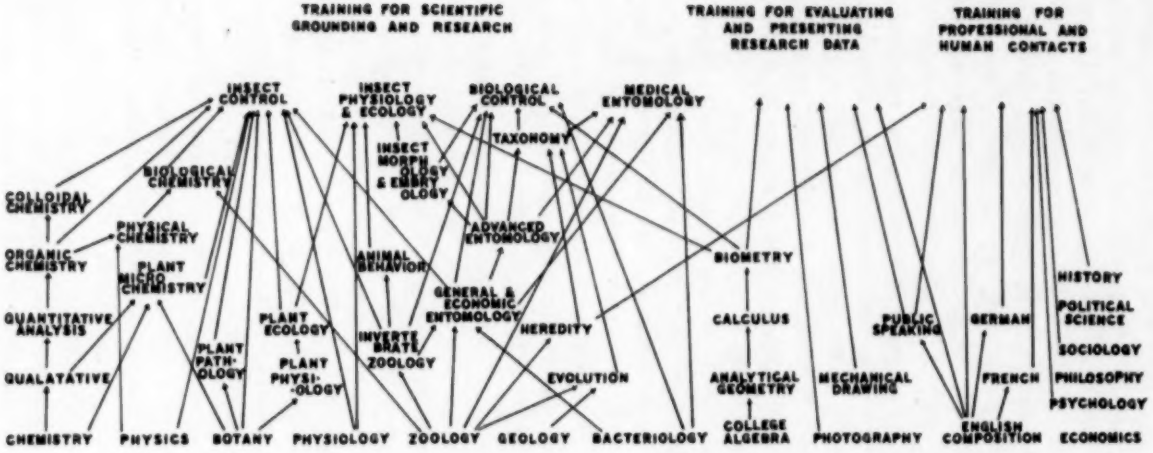


Fig. 1.—A diagrammatic representation of the more important curricular material showing the important interconnections and their sequence.

search. A presentation of this type is a decided stimulus to any wide awake student entering the field of research.

It should be stated however that regardless of how much we may strive to train a man in the proper way if he lacks the spirit of cooperation or a personal attitude of adaptation to a group of coworkers he will probably fail in his research in spite of his ability or mental achievements. Other things being equal personality and attitude are fundamental considerations.

The ascertaining of academic degrees should not be confused with the problem of training. A student may receive a degree as a result of proficiency of certain training. On the other hand, a man may be well trained without receiving a degree, or a degree may be granted by merely the presentation of a thesis, a publication or the payment of a small fee. Therefore the degree which a man holds does not necessarily represent broad training.

THE OBJECTIVES.—With these ideas regarding training and those which have already been presented, the objectives might be stated thus.

1. To develop to the highest degree the personality of the man being trained for research work and then to place him in the position which is best suited for such a personality.

2. To train him as strongly as possible in the fundamental sciences, especially chemistry, physics, mathematics, botany, zoology, physiology, geology and bacteriology, the proportions of each to be determined largely by the major field which is chosen in entomology.

3. Such training should accomplish the next objective which is to teach a student to think clearly in terms of cause and effect regarding problems which may involve many fields. A knowledge of chemistry, physics, plant physiology, plant micro-chemistry and entomology for instance, may all be important factors in the solving of an insect problem.

4. To give the student a reasonable amount of liberal education to broaden and balance his viewpoint and help him acquire a mastery of some of the fundamental factual information needed in his chosen and other fields. This should prove valuable in relation to his professional and human contacts.

5. To develop in the student a knowledge of methods and technique, a familiarity with experimental methods, a philosophical point of view and a maturity of judgment. This is most easily accomplished in the atmosphere of a graduate school. Here the student comes in contact with research projects under way in various lines of work, he receives graduate training, enters into seminar discussions, exchanges ideas with graduate students and faculty in various scientific fields and has access

at all times to council and discussion of a group of entomologists interested in different specific phases of entomology. It is difficult to gain elsewhere this type of training and stimulus and to catch as broad a vision of fundamental research.

6. To acquaint the student with the enormous volume of literature pertaining to his special and closely related fields and to teach him especially where and how to look for information and if possible enable him to interpret, evaluate, organize and use it in an intelligent manner both as a working basis and for research. This is a necessary part of an entomologist's equipment.

7. To fit the student to evaluate, organize and express or report the results of his research in accurate, clear and concise written form. This includes a thorough preparedness in fundamental English so that it may be used fluently, accurately and forcefully, also a knowledge of methods of condensing and illustrating large quantities of detailed data in clear and concise graphs, curves and diagrams as well as the use of properly prepared photographs and drawings.

ON THE HEREDITARY ABILITY OF CERTAIN INSECTS TO TRANSMIT DISEASES AND TO CAUSE DISEASE-LIKE INJURIES TO PLANTS[1]

By F. W. Poos and Nancy H. Wheeler, *U. S. Department of Agriculture, Bureau of Entomology*[2]

In the course of studies on leafhopper injury to legumes and investigations undertaken to determine the nature of the injury to alfalfa and other forage-crop legumes caused by *Empoasca fabae* (Harris), one of the first facts to be determined was whether or not the ability of the leafhopper to cause this injury was hereditary. For this purpose experiments were started during 1929 at the Arlington Experiment Farm (P. O., Rosslyn, Va.). At the same time feeding tests were carried on to determine whether this injury to alfalfa was a disease, involving an infectious entity, or simply a diseaselike injury attributable to some other cause or causes. Eventually evidence was procured through histological

[1]This paper reports the results of one phase of a cooperative study of leafhopper injury to legumes made by the Division of Forage Crops and Diseases, Bureau of Plant Industry, and the Division of Cereal and Forage Insects, Bureau of Entomology, U. S. Department of Agriculture.

[2]Grateful acknowledgment is made to J. W. Scrivener and Floyd F. Smith for much valuable assistance with details of the experimental work reported in this paper.

studies (*15*)[3] and microchemical tests (*14*) which substantiated the theory that the apparent disease is merely a diseaselike injury resulting from the deposition in the vascular tissue of a highly insoluble sheath that probably interferes with the normal translocation of plant materials.

This paper reports the results obtained in testing the ability of *E. fabae*, through heredity, to cause the diseaselike injury to legumes and other crops and the inability of infective adults of *Myzus persicae* Sulz. to transmit through their offspring the disease of spinach known as blight. The distinction should be kept clearly in mind between the type of inheritance discussed in the case of *E. fabae*, which inherited the ability to cause diseaselike injury to its hosts, and that of *M. persicae* Sulz., infective adults of which were found unable to transmit to their offspring the causal agent of spinach blight. It is desired to clearly differentiate between the ability of the infective parents to transmit a virus to their offspring and the inability of these offspring to inherit a virus or any biological entity causing disease. The causal agent of a plant disease can not be inherited, although it may be transmitted from one generation of its insect vector to the next through contamination. The ability to transmit a disease to plants or to cause a diseaselike injury to them is frequently definitely heritable by the insect involved.

REVIEW OF LITERATURE.—A review of the literature on plant diseases transmitted by insects and on diseaselike injuries caused by insects reveals a varying degree of completeness in the ability of certain insects to transmit plant diseases and the ability of other insects, through heredity, to cause diseaselike injuries to plants. No attempt is made to include all references to the general subject, but only some which pertain to this particular phase of the matter.

Pack (*10*) found that the squash bug, *Anasa tristis* (DeG.), transmitted, through the egg from one generation to the next, the ability to cause plant injury, when nymphs hatching from eggs were removed to petri dishes and then placed on healthy squash plants protected by cages.

Linford (*7* and *8*) reported that adults of *Thrips tabaci* Lind. did not transmit the pineapple yellow-spot virus in Hawaii, unless they became infective as larvae, and that the virus then survived pupation.

Samuel and Bald (*12*) also have shown it to be essential for the thrips, *Frankliniella insularis* Frankl., to feed on the diseased plant in the larval stage before the adult can transmit the tomato spotted wilt in Australia. In contrast to these findings, Richards and Blood (*11*) reported

[3]Italic numbers in parenthesis refer to Literature Cited, p. 68–69.

that the tomato psyllid, *Paratrioza cockerelli* Sulc, is constantly associated with psyllid yellows of the potato, that this injury is in some way induced only during the feeding process of the nymphs of this insect, and that the adult forms appear incapable of producing psyllid yellows symptoms on potato plants, either in the field or in the greenhouse.

Storey (*20*), in 1932, in studies of the inheritance of the ability of *Cicadulina mbila* Naudé to transmit the streak disease of maize, showed that even the *ability to transmit* is a hereditary character, some races having been bred which are able and others unable to transmit the virus to maize plants in the course of the natural feeding process. The crossing of pure races demonstrated that the ability to transmit is inherited as a simple dominant Mendelian sex-linked factor.

With reference to the green spotting of pineapple plants caused by the feeding of the pineapple mealy bug, *Pseudococcus brevipes* (Ckl.), Carter (*2*) reports that the ability to produce green spots is transmitted from the mother to her young and is limited to certain individuals in the colony. According to the evidence obtained by this writer, green spotting is not the result of infection of the plant by a specific organism, but is rather a response by the plant to a secretion of the mealy bug which is specific to certain individuals, but not common to the species. He states that the secretion is, no doubt, the end result of the operation of some internal factor on the physiology of the insect. He regards the "hereditary nature of this factor" as being probably concerned with symbionts of this insect.

The only definite report of an adult insect being able to transmit to its offspring a plant disease, which has come to the attention of the writers,[4] was published in 1918 by McClintock and L. B. Smith (*9*). These authors stated that "the infections obtained of blight indicated that the young became associated with the infectious entity previous to their birth," and they concluded "that the causal factor of the disease may be hereditary with the aphids" and might survive the summer by this method. Although these writers recognized, through the wide range of food plants of certain aphids, the possibility of alternate hosts of the inciting factor of spinach blight, the host range of this disease had not been completely determined and at that time "carrier plants," as reported by K. M. Smith in 1930 (*17*), were unknown. McClintock and Smith

[4]After this manuscript was in press a paper by T. Fukushi (Proc. Imp. Acad. Japan 19 (8) : 457–460. 1933) was received, reporting transmission of the virus of dwarf disease of rice in Japan through the eggs of its insect vector, the leafhopper, *Nephotettix apicalis* Motsch. var. *cincticeps* Uhl.

(*9*) have been referred to in the literature innumerable times, and many references have been made that cast doubt upon the particular conclusion just quoted. Among the first of these was by F. F. Smith, in an unpublished thesis in 1924, at the Ohio State University. In a condensed form of this thesis, published in 1925 (*13*) he reported that "*Aphis rubiphila* Patch was the only insect carrier of leaf curl among several insects used .....The infective agent is not inherited by the offspring in viviparous reproduction." His results caused him to doubt that infective parent insects transmit the agent of a plant disease to their offspring.

Hoggan (*3*), in 1930, in discussing experiments with transmission of cucumber mosaic to spinach, the symptoms of which she found strikingly similar to spinach blight, mentioned the report of McClintock and Smith regarding the ability of infective parent aphids to transmit the infectious entity directly to their progeny up to the fourth generation. Later (*4*),[5] in 1933, from experiments with some viruses affecting spinach and certain aspects of insect transmission, using *Myzus persicae* Sulz. and *Illinoia solanifolii* (Ashm.), she stated that no evidence was procured of any direct transmission of the virus from infective parent aphids to their progeny. In these experiments 10 nymphs to each of 15 plants, making a total of 150 offspring from infective parents on cucumber-mosaic spinach, were transferred and allowed to remain on healthy spinach plants for a week or more.

Although nothing else has been found in the literature indicating that an infective parent insect can transmit a plant disease to its progeny, many cases have been cited where insects have transmitted important plant diseases. Some of the more important ones are: Curly top of sugar beets, which, as far back as 1905, was first connected with *Euttetix tenellus* (Bak.) on circumstantial evidence by Ball (*1*) and later was found by Stahl and Carsner (*18*) not transmissible by infective adults of *E. tenellus* to the offspring of these adults; aster yellows, which Kunkel (*6*), in 1924, showed was readily transmissible by *Cicadula sexnotata* Fall. only after this leafhopper had fed on diseased plants; and streak disease of corn, the transmission of which Storey (*19*) first reported in 1925, through the agency of *Cicadulina mbila* Naudé. K. M. Smith (*16*) working with *Myzus persicae* Sulz., reported that "experiments carried out during two years on the question of the inheritance of the leaf-roll virus by the progeny of infective aphids proved negative. It is therefore

[5]Since this manuscript was prepared, another paper relating to this subject has been published: Hoggan, Ismé A. Some factors involved in aphid transmission of the cucumber-mosaic virus to tobacco. Jour. Agr. Res. 47 (9): 689–704. 1933.

assumed that the virus is not hereditary in the offspring of the aphis." Kirkpatrick (*5*), in his studies on leaf-curl of cotton in the Sudan, found that the virus causing the disease was transmitted by means of whiteflies (*Bemisia gossypiperda* Misra and Lamba) and that adults, developing from larvae which had fed on infected plants, could transmit the disease, but that the virus could not be transmitted through the egg, though uninfected adult aleurodids could pick up the virus in three hours and transmit it to healthy plants in 30 minutes.

EXPERIMENTS WITH *Empoasca fabae* (HARRIS).—In order to test *E. fabae* as to whether it inherited the ability to cause the diseaselike injury to alfalfa and red clover, a number of females from a pure culture of this species were placed upon cowpea or potato plants in cages (pl. 1, fig. 1) to deposit eggs. After two days the cages and adults were removed.

TABLE 1. TESTS ON THE INHERITANCE BY *Empoasca fabae* (HARRIS) OF THE ABILITY TO CAUSE INJURY TO ALFALFA AND RED CLOVER, ARLINGTON FARM ROSSLYN, VA., 1929

Generation	Dates of hatching	Number of nymphs		Number of positive tests
		Transferred	Escaped or died	
First	June 26–July 1	63	23	40
Second	July 27–Aug. 2	83	45	38
Third	Aug. 31–Sept. 20	86	38	48
Sixth	Dec. 11–17	17	4	13

As soon as hatching was expected the plants were observed for emergence of the nymphs. As the eggs hatched (pl. 1, fig. 2) the nymphs were removed by means of a small camel's-hair brush *before they fed or moved about* upon the plants from which the eggs had hatched and upon which their parents had previously fed. Transferring the nymphs in this stage of development before they were sufficiently developed to be handled readily without being injured, caused most of the mortality recorded in column 4 of Table 1. Hatching was concentrated during the early part of the morning, for the most part, by keeping the plants containing the eggs in an ice box at night during the period when hatching was expected. The nymphs literally popped out of the plants, as is illustrated in plate 1, figures 3 and 4, showing, respectively, the embryo before the chorion of the egg was ruptured and the eggshell on the surface of the cowpea petiole after hatching was completed.

As the nymphs were removed from the cowpea plants they were placed, one to a cage (pl. 2, fig. 6), on seedling plants, about 2 inches in height, of either Hairy Peruvian alfalfa, Kansas Common alfalfa, Russian red clover, or Michigan red clover growing in 8-inch flowerpots. These plants were caged by means of open-end glass vials, 5 inches in length

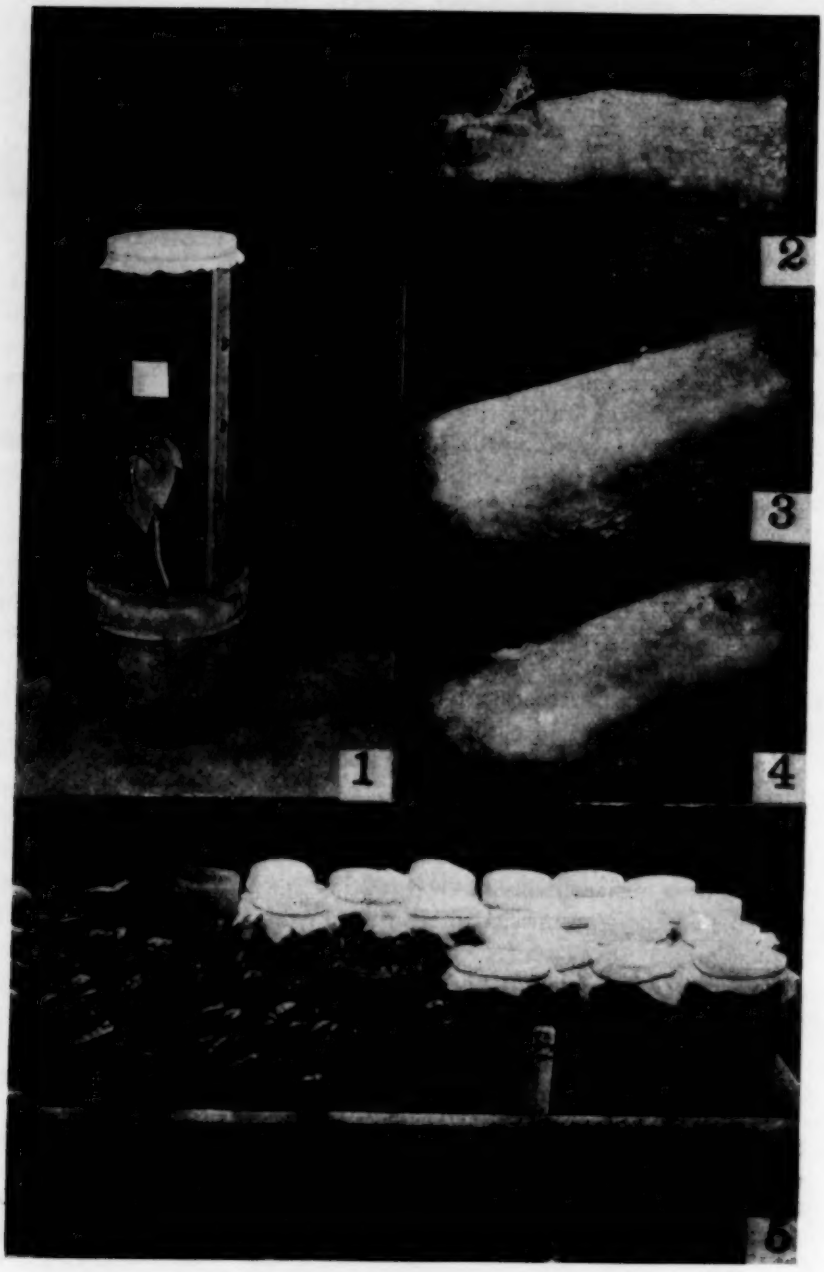
and 1 inch in diameter. One end was pressed into the soil and the other was plugged with a cotton stopper or covered by means of cheesecloth which was held in place by rubber bands.

Injury to the plants (pl. 2, fig. 6) upon which these nymphs had been placed in these cages was usually evident in from 24 to 48 hours. In many instances a plant was injured beyond recovery within a period of 48 hours' feeding by a nymph. When these plants became too much injured to furnish suitable food for their respective nymphs the latter were transferred to cowpea plants (grown free from *Empoasca* in the greenhouse) to develop to the adult stage. After sufficient time had elapsed to allow for oögenesis and fertilization the adult females were placed upon insect-free cowpea plants to deposit their eggs, the hatching of which was observed in order to test the ability of the nymphs to injure the plants. After the third generation had been tested in this manner and no individuals had been found which did not inherit the ability to cause the diseaselike injury to seedling alfalfa and red clover, the *Empoasca* progeny of the fourth and fifth generations were not similarly tested; individuals of the sixth generation, however, were tested in the same manner as the first, second, and third generations of this *Empoasca fabae* material, with results identical with those obtained in the earlier experiments. The results of these tests are briefly recorded in Table 1. With these data as a basis it seems justifiable to conclude that *E fabae* inherits the ability to cause the diseaselike injury to legumes and other crops. In a large variety of experiments at Arlington Experiment Farm during the period 1928–1933 all individuals, both as nymphs and as adults, observed for this purpose caused the characteristic diseaselike injury, and no sex-linkage factor was found.

EXPERIMENTS WITH APHIDS AND SPINACH BLIGHT.—In connection with the inheritance tests with *Empoasca fabae*, experiments with *Myzus persicae* Sulz. primarily and with a few specimens of *Illinoia solanifolii* (Ashm.) in the transmission of spinach blight from infective parents to their progeny were started early in 1930 and continued at various intervals until the spring of 1933. In the earliest experiment the uninfected spinach plants to which infective aphids were transferred were grown from purchased seed of varieties considered susceptible. At first all results were negative, and it was thought, perhaps, that a blight resistant strain may have been furnished. Thereafter, in order to ensure susceptibility, seed was used from the lots of the same varieties that had previously produced plants showing a considerable amount of blight under field conditions.

Optimum weather conditions for these experiments seemed to be those

Plate 1



of warm clear days in late fall or early spring. Infected plants, heavily infested with aphids, were usually collected about 8 a. m. while it was still cool and the aphids remained inactive. Pieces of healthy spinach in readiness to receive aphids from the infected plants were placed in 2-dram sterilized homeopathic vials. Mature aphids were carefully selected and removed with a camel's-hair brush, usually one to each vial. Each parent was constantly watched and as each offspring was born it was gently removed before it had an opportunity to feed or to move away from the mother. In some instances several offspring were procured from a single parent, in which case they were all placed in the same cage. In other cases as soon as one offspring was born both parent and offspring were removed, each to separately caged plants, a flat of caged plants being reserved for the parents and another for the offspring (pl. 1, fig. 5). In a few instances similar tests were made with parents only, transferred directly from blight-infected spinach to healthy plants, in most cases five aphids being placed together in each cage.

Both out-of-door cheesecloth cages (3 feet by 3 feet by 3 feet) and celluloid cages in flats in the greenhouse (pl. 1, fig. 5) were used. The transfers in the field cages were not very successful, and the best results were obtained from spinach planted in the flats in the greenhouse. On this the aphids were confined to individual plants in celluloid cages about 3 inches in diameter by 5 inches in length, with one end pressed into the soil and the open end covered by cheesecloth held in position by rubber bands.

Observations on all plants were made at various intervals and, after sufficient time had elapsed, all cages were removed. A record was then made of the parents, dead or missing; the number of aphids killed, both in parent and offspring cages; and any abnormal condition observed in the plants. A thorough fumigation was then given the plants to insure the destruction of any remaining insects, and observations at intervals

PLATE 1

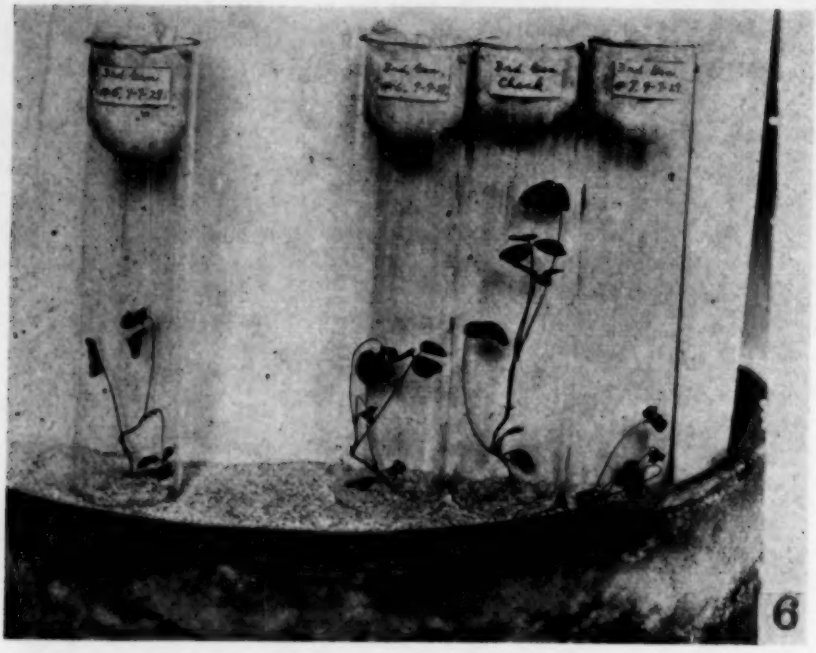
Fig. 1.—Celluloid cage used to confine adult females of *Empoasca fabae* (Harris) upon cowpeas for oviposition.

Fig. 2.—Nymphs of *Empoasca fabae* (Harris) emerging from petiole of cowpea.

Fig. 3.—Two embryos of *Empoasca fabae* (Harris) just before chorion of egg is ruptured. The dark spots represent pigment in the eyes.

Fig. 4.—Eggshell of *Empoasca fabae* (Harris) on the surface of the cowpea petiole just after hatching was completed.

Fig. 5.—Flat of spinach showing celluloid cages used for confining offspring or parents of *Myzus persicae* Sulz. to individual plants to test the ability of infective parents to transmit to their offspring the causal factor of spinach blight.



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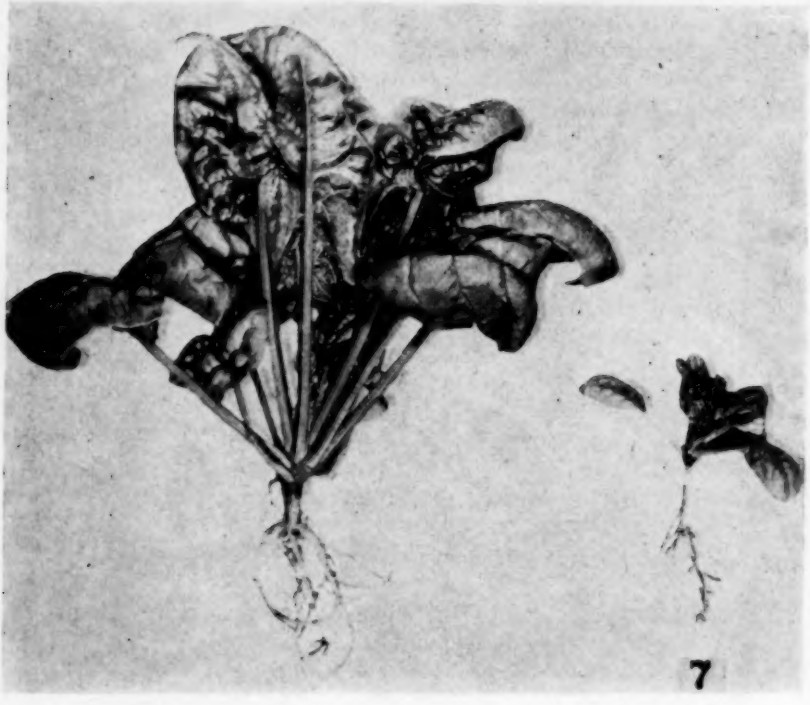

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of two or three days on all plants were continued until the experiment was closed.

A total of 25 experiments with aphids on spinach were conducted over a period of three years. Of these, 18 were experiments with parents from infected spinach, together with their offspring born after the parents had been removed to healthy spinach, and seven were experiments with adults (three or five to the cage) transferred directly from infected to healthy spinach plants. A total of 908 adults were transferred, of which 221 died from a fungous disease (caused by *Empusa aphidis* Hoffm.) before the cages were removed. A total of 909 offspring were transferred, these being removed immediately from parents which had been on infected spinach prior to the birth of the offspring. A total of 333 cages of parent aphids and a total of 304 cages of offspring of these parents were established. Of the plants caged with parent aphids, 224 remained normal, 31 showed symptoms of blight infection in various stages, and 78 were otherwise injured. The low percentage of typically infected plants obtained in these cages was probably caused by unfavorable weather conditions resulting in masked smyptoms; the lack of large aphid populations and the lack of extremely susceptible spinach probably were contributing factors. Of the plants caged with aphid offspring, 258 were normal, none *showed infection*, while 46 were otherwise injured. Plate 2, fig. 7, shows the injury resulting to a plant infested with infective parent aphids contrasted with a plant infested at the same time with the offspring of these aphids. In all instances where the plants appeared to be stunted, dwarfed, or irregularly developed, they were considered as otherwise injured.

It was noted, in the experiments where adults alone were transferred directly from infected to healthy spinach plants that in four out of the seven experiments blight infection was produced, the total number of normal plants being 17 and that of blight-infected, 11. A higher percentage of infection was obtained by an immediate transfer of the aphids from infected to healthy plants, showing a possible greater infective power of the adults when transferred directly, as contrasted with results

PLATE 2

Fig. 6.—Glass vial cages in which newly hatched nymphs of *Empoasca fabae* (Harris) were confined to seedling plants to test their ability to cause diseaselike injury. Note varying degree of injury to infested plants compared with uninfested plant in second cage from right.

Fig. 7.—Spinach plants infested with *Myzus persicae* Sulz.: At right, with blight infective parents; at left, with offspring of these parents.

obtained when the adults were removed from infected plants for a period of from 1 to 6 hours while the production of offspring was being awaited.

It was of special interest to note that none of the offspring produced by the 221 parent aphids referred to above, which died because of the fungus, became infected by this fungous disease.

Basing conclusions upon the data obtained from these experiments, it would therefore appear that infective parents of *M. persicae* do not transmit to their offspring the virus of spinach blight, and that the ability of the adults to infect healthy spinach plants with this blight is decreased by their removal for several hours from infected material.

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THE GREEN JUNE BEETLE IN LAWNS

By W. A. PRICE

The Green June Beetle (*Allorhina nitida*) has been the subject of many inquiries, and the object of much discussion in Kentucky during the past few years. The problem of its control has found its way into the horticultural meetings where growers have complained of beetle injury to the ripening fruit, particularly apples, grapes and peaches. Golfers and golf club managers have called attention, frequently, to damage on the greens caused by the grubs. Here their habits of tunneling and burrowing have resulted in small mounds of loose dirt and a soft, mellow turf, conditions very undesirable on the greens. During late September and early October complaints and inquiries were received from home owners in Lexington, Ky., concerning the grubs and their activities in lawns. One of these lamentations was rather unique. The party reported that "thousands of fat worms crawling on their backs had congregated in the street and died, and the odor coming from them was terrible." On visiting the place it was found that there had been no exaggeration. Thousands of worms had fallen over the curb and died and the odor was as described.

However this was only an annoyance, the real damage was to the lawn. On warm wet evenings the grubs migrate and build vertical and horizontal tunnels. The latter are made near the surface of the ground and among the grass roots. This not only partially uproots the plants but makes the soil so loose and porous that it soon dries out so that the grass dies. The condition is aggravated by deep vertical tunnels, constructed as retreats. Often these are 12 to 15 inches in depth and the loose coarse dirt excavated at night is piled up in little mounds two to three inches in diameter. This is not only unsightly in the lawn but adds to the injury of the grass plants that survive.

Arcadia Park where the grubs were found in such large numbers, consists of one paved street which is U shaped. The lawn cuttings are thrown in piles on the vacant lots and fields in the rear. These piles of decaying grass serve as a lure to the female in laying eggs, or furnish excellent conditions for the development of the grubs. The history of every lawn infestation that has come to my attention shows that the grubs have developed in these piles of grass cuttings and later migrated to the lawn. The same is true of golf greens. There is a practice common among greens keepers to cut the grass and dump it in a pile back of the green and opposite the approach. During the egg laying season I have observed swarms of the beetles hovering over these piles of trash. Here the grubs develop partially and later migrate to the greens.

As a matter of protection to the greens as well as the lawns, grass cuttings should be trucked away or be dumped at a distance sufficiently great to prevent migration of the grubs into any lawn or green.

In all cases of injury to lawns that I have investigated the grubs, nearly full grown, have migrated in, and their progress across the yard as indicated by their mounds has been gradual. When this condition is noticed, barriers in the form of wooden troughs sunk into the ground will stop their ingress and progress. Two such barriers will be sufficient. One should be placed at the end of the yard where the grubs are entering and the other with the first, should enclose the infested lawn area. This arrangement will prevent the entrance of additional grubs and at the same time enable one to trap those in the infested area.

If the board troughs, made by nailing together three boards of ¾ x 3 inch dimensions, are sunk into the ground surrounding the infestation and left in place long enough the grubs will be caught in the traps due to their natural habits of migration. However, if the traps are unsightly and it is desirable to rid the lawn of the pests quickly, the process can be hastened by the use of liberal amounts of water applied to the soil. If city water is available, the nozzle should be removed from the hose and the water allowed to run until the soil is well soaked. Since the inhabited burrows are for the most part vertical and large, flooding water soon fills the tunnels and the grubs come to the surface of the ground. Some will crawl in the open while others will remain at the mouth of the burrow. In either instance they can be collected with forceps without great difficulty. The amount of water required will depend somewhat on the soil. In rich loam soils where these experiments were carried

Plate 3; 1.—Trough three inches deep along border of the yard. Vacant lot on right from which grubs migrate; 2.—Section of trough surrounding infested area.

PLATE 3

1

2

out 15 gallons of water was used per square yard of turf. The grubs began crawling on the ground 20 minutes after the flooding operation was started. If greater celerity is desired it can be obtained by using an extract of pyrethrum. One ounce of the commercial extract was diluted with four gallons of water and this sprinkled on the ground at the rate of one gallon to one square yard of surface. The ground was then watered and the grubs began coming to the surface within five minutes from the time the water application was started.

If it is not desirable to pick the worms from the ground, under ideal conditions they can be trapped in an evening, by flooding the ground inclosed by the wooden troughs. If possible select a warm evening following a rain.

Summary

1. Prevent infestations in lawns and greens by proper disposition of grass cuttings.

2. A barrier in the form of a trough sunk in the ground will prevent migrations into the lawn from the nearby grass pile or other decaying vegetation.

3. Established infestations in lawns can be cleaned up by surrounding them with troughs and thoroughly soaking the soil in the evening with water.

4. The use of pyrethrum extract will bring the grubs to the surface of the ground more quickly than water alone.

The Green Trogositid Reared From Walnuts. (*Temnochila virescens* **Fabr.**) An English walnut containing a larva of *Temnochila virescens* Fabr. was brought into the laboratory in December, 1932. Since this beetle is known as a predator, it was thought that the walnut had been infested by some other insect and the trogositid larva had entered to feed on the other insect. To determine this point, the larva and walnut meat were placed in a breeding cage for observation. It was observed that the larva continued to feed on the meat of the nut. In June the larva molted, later pupated, and emerged as an adult in December, 1933. Most of the nut had been consumed. The beetle was identified by Dr. W. J. Chamberlin, Oregon State College, as *Temnochila virescens* Fabr.

B. G. Thompson, *Asst. Entomologist, Oregon State College and Experiment Station*

BARIUM FLUOSILICATE (DUTOX) IN BLISTER BEETLE CONTROL[1]

By HARRY F. DIETZ and E. E. ZEISERT, *Wooster, Ohio*

For the past three years (1931–1933) outbreaks of blister beetles have occurred in north central Ohio. The 1931 outbreaks were not of sufficient intensity to attract much attention, but the intensity and the extent of the 1932 and 1933 outbreaks brought numerous requests for information regarding the control of these pests.

Two species were involved in the general outbreaks, namely, the margined blister beetle, (*Epicauta marginata* LeConte) and the black blister beetle, (*E. pennsylvanica* De Geer). A purely local and inconsequential outbreak of the pear blister beetle, (*Pomphopoea aenea* Say) occurred at Wooster early in May 1931.

In the course of each of the three seasons, the black blister beetle has followed the margined blister beetle in regular sequence. The appearance of the black blister beetle in destructive numbers was much earlier in northern Ohio than the dates given by Blatchley (1). Thus this species has not proved to be an "essentially autumn insect." On the other hand, the margined blister beetle first appeared in destructive numbers on July 20 in 1932 and on July 11 in 1933, both of which dates are later than those recorded by Blatchley. In 1932, a few individuals of the black blister beetle were found along with the margined beetle and the destruction wrought by these pests during that year was by mixed infestations of the two species. In 1933, however, the outbreaks of the two species were much more clearly defined.

One of the interesting features of these blister beetle outbreaks, over a three year period, was the almost total absence of the striped blister beetle, (*Epicauta vittata* Fabricius). In the hope that sufficient numbers of this insect might be found for insecticide test purposes, a number of reports of its abundance were investigated without favorable results.

THE STATUS OF INSECTICIDES IN BLISTER BEETLE CONTROL.—There is considerable divergence of opinion on the efficacy of various toxic materials in the chemical control of blister beetles. Arsenical sprays and dusts are recommended in most of the general publications as the control for these insects.

However, in the literature dealing with blister beetles we find such statements as those of Blatchley and of Metcalf and Flint (3).

[1]Approved for publication as a Contribution from the Grasselli Research Grant at the Ohio Agricultural Experiment Station.

The former states that, "arsenites kill them slowly, and a swarm that feeds a day or two before application is made and a day or two before the specimens die has done about as much injury as would have been caused, without treatment of any kind." The latter say that, "blister beetles are repelled by or resistant to arsenicals" and recommend sodium fluosilicate dusts, or sprays of calcium arsenate or Bordeaux.

The work of Milliken (4) in Kansas shows plainly that high concentrations of arsenicals are required to kill these insects, particularly the larger species.

The senior author (2) found that a 1 per cent concentration of nicotine oleate was a very effective control measure, but this material has not come into general use because of the difficulties attendant upon its preparation and dispersion in water, as well as its cost.

On the other hand, Webster (5) states that these insects are no economic problem in well sprayed potato plantings in Iowa, a statement that applies to large, well sprayed potato acreages in north central Ohio. However, a considerable number of truck crops and ornamental plants that are fed upon by blister beetles, do not require the frequent and heavy Bordo-calcium arsenate sprays that must be applied to potatoes.

On the whole the status of the chemical control of these insects may be regarded as unsatisfactory. A simple, effective control and one that can be quickly applied with comparative safety to plants is desirable at such times when swarms of blister beetles swoop down upon and sweep thru gardens, all in the brief period of a few days.

Dusting offers the most simple, and most rapid method of applying insecticides to truck crops and ornamentals. Hence, the problem was the finding of a dust that would quickly kill these insects.

THE NATURE OF THE EXPERIMENTS.—The experimental work was divided into two parts as follows:

(1) Laboratory tests to determine the relative insecticidal efficiency of various materials.

(2) Field tests, to determine whether materials that showed promise in laboratory tests would perform equally well under field conditions.

LABORATORY EXPERIMENTS.—Sixteen series of laboratory experiments involving the use of more than 5,000 insects, were conducted and several methods of approaching the problem were tried.

The first of these methods may be termed the "exploratory method" in which high concentrations of materials were used. Ten insects were employed, as a rule, in each test and the tests repeated several times.

With dry materials, such as the arsenates of lead, calcium, and manganese or with barium fluosilicate the following procedure was employed.

300 mg. of the undiluted compound was placed in a 250 ml. flask. The insects were introduced, gently shaken with the dust for 30 seconds, and then removed by pouring them into a small screen cage. After the excess dust had fallen off of the insects they were supplied with a suitable portion of fresh goldenrod flowers and confined in ordinary jelly tumblers covered with cheese cloth. This made possible the observation of the insects at short and regular intervals.

The three arsenates: lead, calcium, and manganese, as well as barium fluosilicate appeared to be equally toxic when used undiluted; a 100 per cent mortality occurring at the end of a 20-hour period. Kaolin, a supposedly inert dust, gave an average of 70 per cent mortality under the same conditions.

With liquids, such as the plant extractives; pyrethrum, derris, and free base nicotine, the procedure was quite similar. The insects, confined in small screen cages, were immersed in 1.5 per cent concentrations of the plant extracts which had each been dispersed in a 0.4 per cent coconut potash soap (containing 40 per cent soap on a dry weight basis). After such immersion and when all excess liquid had drained from the thoroughly wetted insects, they were confined as before with fresh goldenrod flowers in jelly tumblers.

As long as the insects were wet, they remained immobile, but, movement and recovery began as soon as they dried. The total mortality based on records taken at the end of 48 hours were as follows:

Material	Active ingredient	Dead
Pyrethrum Extract	(2.15 per cent pyrethrins)	75 per cent
Derris	(4.5 per cent plant resins)	0 per cent
Nicotine (50 per cent free base)		80 per cent

These tests did not warrant further tests with more dilute application of these materials.

The second type of experiment was the conventional "cage test". Insects which had been thoroughly dusted were confined in large, well-aerated, cylindrical screen cages along with suitable food which had likewise been dusted, in order that conditions which would result from field dusting would be simulated.

The problem of securing uniform and equal coverage applies to both laboratory and field experiments with dusts. This problem is further complicated by the fact that dusts of different composition both in quantity and kind of toxic agent as well as diluents, may present wide differences in density. This in turn raises the question as to whether measured volumes or equal weights of material should be applied. Both

methods were tried and altho the relative efficiency of various dusts remained unaltered, irrespective of which method was used, we believe that the use of equal weights of materials gives more reliable results than measured volumes.

In the earlier cage tests one or two replications (that is 2 or 3 cages) each containing 10 insects or one cage containing 30 insects were used for each treatment.

In the later tests certain refinements were introduced. Three replications (4 cages) each containing 25 or 30 beetles were used. Since as many as 28 cages were used in a series errors such as the effect of uneven lighting, differences in air currents, and resultant differences in relative humidity, might easily be introduced through the positions occupied by the cages receiving a particular treatment. These were avoided through the use of a purely randomized system of distribution. No two cages, treated alike, occurred in the same position in any row in either direction or in the same row more than once. Furthermore, in making these tests all materials or combinations thereof were coded and applied by one of us. The other, who was unfamiliar with both the code and the compounds used, made the observations and recorded the results. These were then tabulated and decoded. Until this final operation, the performance of any material remained in doubt.

The figures given in Table 1 represent the average performance of any given toxic agent and diluent under all the experimental conditions that were imposed.

TABLE 1

Material	Number of experiments	Percentage kill 24 hour	48 hour	60 hour
Lead arsenate—flour[1]	6	4.0	20.0	35.0
Barium fluosilicate—flour	16	78.0	89.0	96.0
Barium fluosilicate—clay	4		89.0	95.0
Lead arsenate—lime	2	7.0	40.0	40.0
Calcium arsenate—lime	10	33.0	43.0	60.0
Barium fluosilicate—lime	11	54.0	59.0	78.0
Lead arsenate—talc	4		69.0	84.0
Calcium arsenate—talc	4		74.0	81.0
Barium fluosilicate—talc	4		96.0	97.0

[1]The ratio of toxic agent to diluent in all cases was 1–4 by weight.

The following facts are shown:

(1) That barium fluosilicate (Dutox) when used one part by weight and diluted with 4 parts by weight of flour, talc or clay gave a uniformly high percentage of kill in as short a time as 24 hours.

(2) When lime was used as a diluent for barium fluosilicate the efficiency of this toxic agent was apparently reduced. These results are not

in accord with those obtained by other workers who have successfully used barium fluosilicate-lime dusts in field tests in the control of other insects.

(3) The use of lime with arsenicals in order to avoid plant injury is generally recommended, but this addition likewise reduces the efficiency of these toxic agents.

(4) Neither lead arsenate or calcium arsenate equalled or approached barium fluosilicate in insecticidal efficiency against blister beetles.

FIELD EXPERIMENTS.—In field dusting experiments, we have taken cognizance of the following facts: first, that small quantities of dust are difficult to apply uniformly. Even the application of quantities as small as 10 pounds per acre presents difficulties, unless certain types of dusters are used. Diluted dusts were chosen as most practical in order to avoid plant injury that might result from the application of excessive quantities of undiluted toxic materials. We have considered the diluent merely as a carrier by means of which a comparatively small quantity of toxic agent could be distributed over a very large area. Therefore, the amount applied per acre was proportional to the quantity of toxic agent in a given dust. If, for example, 5 pounds of toxic agent in 100 gallons of water is considered an effective dosage when applied to an acre, then a dust, containing one part of toxic agent and four parts diluent would be applied at the rate of 25 pounds per acre, so that this amount of toxic agent would be present.

Secondly, different kinds of plants, or plants in different stages of growth present varying requirements of treatment as to quantities of dust applied.

Since there is little agreement among entomologists on the best ratio of toxic agent and diluent in different dusts, on what basis different dusts should be compared or how much should be applied to a definite unit area, we have empirically adopted the 1–4 toxic agent-diluent ratio to be applied at a uniform rate per acre and have kept it constant thruout our experiments.

In the nine field experiments conducted in 1932, barium fluosilicate-flour and barium fluosilicate-lime dusts were tested at the rate of from 25 to 35 pounds per acre depending on the size and kind of plants. In all cases, these combinations were very effective as was shown by the large numbers of dead beetles on the ground within 24 hours, the absence of live beetles on the treated plants, and no evidence of the migration of the beetles.

During that year we observed two plots one of which had been sprayed with lead arsenate, 4 pounds to 100 gallons, the other which had received

a light dusting with undiluted lead arsenate. In neither case was any control obtained nor were the beetles deterred from feeding. No dead insects were found.

The flour used as a diluent during 1932 was the cheapest grade of baking flour purchasable and because it cost little more than lime, and also, because of its adhesivity it was considered as the best diluent. However, by the time the 1933 outbreaks occurred the cost of this flour had doubled, so that some lime was substituted in the mixture.

The following combinations were used at the rate of 25 to 35 pounds per acre in the seven field tests conducted in 1933: barium fluosilicate 1, flour 3, lime 1; and barium fluosilicate 1,flour 2, lime 2. All gave a high percentage kill of the beetles, complete protection of the plants, and no plant injury.

In all of our dusting experiments, particular effort was made, not only to secure the most nearly uniform possible coverage of the plants, but also to so direct the dust that it would cover the insects. This procedure was followed in order to take advantage of the well known "cleaning" habits of these insects and insure their getting a toxic dosage.

No visible injury to any of the following plants, which were dusted in the course of these experiments, was observed: asters in full bloom, beet, cabbage, calendula, carrots, celosia, corn, egg plant, grapes, gladiolus, lettuce, matrimony vine (*Lycium* sp.), oriental poppy, potato, spinach, and tomato.

All our field dusting experiments were conducted during very dry, hot weather, and under drouth conditions which frequently equalled or approached those of 1930 in intensity but not in duration.

The following conclusion is warranted on the basis of the field experiments: barium fluosilicate dusts offer a simple, effective, inexpensive control for black and margined blister beetles and seem to be safe to a comparatively wide range of plants.

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Mr. Dickison: Did you notice if the spotted cucumber beetles were controlled by fluosilicates?

MR. DIETZ: Yes, we have data from three years' experiments in dusting cucumbers which show that barium fluosilicate dusts control both the twelve spotted and the striped cucumber beetles.

MR. DICKISON: During the tests on potatoes, did you find you controlled flea beetle?

MR. DIETZ: We have separate experiments on potatoes in which flea beetle control is stressed. Where we used barium fluosilicate dusts, with flour or lime as the diluents and without the addition of certain copper salts, our results did not equal those of any of the standard spray materials. However, this year when certain copper salts were added to the barium fluosilicate dusts, the results, in some cases, were better than any from the sprayed plots. All seemed to depend on how the dusts adhered to the plants, especially during rains.

I wish to add here that tuber injury by the larval forms does not frequently occur at Wooster.

MR. J. D. MORTON: In the case of using barium fluosilicate on potatoes, I would ask you if you had damp weather accompanying the burning. I wondered if you know whether the barium combined with carbon dioxide formed a carbonate and if so, by mixing soap with the barium fluosilicate you could prevent burning.

MR. DIETZ: In our experimental work with barium fluosilicate dusts, when flour and lime were used as diluents, we have not encountered noticeable burning. Other investigators have reported burning under humid conditions. Whether it was due to the formation of barium carbonate, I do not know. Fluorine compounds vary widely in their solubility in water. The very soluble ones like the alkali fluorides are toxic to both insects and plants; whereas, the most insoluble ones, like the complex called calcium fluoride, are apparently non-toxic to plants and to most insects, even when high concentrations are used. Barium fluosilicate is one of the few fluorine compounds that is just soluble enough to be highly toxic to insects and insoluble enough to be safe for use on plants. Soaps have been regarded as incompatible with the more insoluble fluorine compounds, because of the danger of their reacting and forming the alkali fluorides which are toxic to plants.

THE EFFECT OF ALFALFA CUTTING SCHEDULES UPON THE OCCURRENCE OF THE POTATO LEAFHOPPER (*EMPOASCA FABAE* HARRIS) AND ALFALFA YELLOWS IN WISCONSIN[1]

By Ed. M. Searls, *Department of Economic Entomology, College of Agriculture, University of Wisconsin*

The experiment from which the following data were taken was instituted for the purpose of verifying field observations to the effect that some growths of alfalfa suffered more from leafhopper injury than other growths which were similar in every respect except the date upon which the immediately previous cutting had been made and to determine, if possible, the reason for this difference in severity of leafhopper injury.

Materials and Methods.—For the purpose of this experiment two parallel, uniform strips of alfalfa running North and South 105 feet long, one 12.5 feet wide and the other 17.5 feet wide were each divided transversely into three contiguous plots of equal length. The strips were about 12 feet apart and separated by a blue grass sod. These plots were numbered from 1 to 6 with plots 1 to 3 in the narrower strip and 4 to 6 in the other.

Each plot was further divided exactly in half transversely and beginning one week after the first cutting date the northern half of each plot was sprayed to control the leafhoppers. The spray used in 1933 was a pyrethrum extract combined with an oxidized sulphonated hydrocarbon. It was applied with a knapsack sprayer at one hundred and twenty-five pounds pressure. Spraying was done after each infestation had been taken and again three days later. During 1932 the treated plots were sprayed each Tuesday with Bordeaux mixture (4–6–50). In every instance the treated half of the plot was designated as the b part of the plot while the untreated portion is referred to as the a portion. The treated portion of plot 1 would therefore be indicated by 1b. This designation of plots was maintained throughout the experiment. Plots 1 and 4 were exactly opposite each other and were considered duplicates. The remaining plots were used in pairs in numerical order. During 1932 the three pairs of plots used in this experiment were subjected to three Different cuting schedules. Plots 1 and 4 were cut once, plots 2 and 5 were cut twice, while plots 3 and 6 were cut three times. The dates of cutting and other yield data of the 1932 season are given in Table 1.

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TABLE 1. ALFALFA YIELD AND THE INCIDENCE OF WEEDS IN SECOND GROWTH FOLLOWING AN EARLY CUTTING COMPARED WITH A DEFERRED CUTTING. MADISON, WIS., 1932.

Plots and treatment	Cutting dates: June 14 Total yield lbs.	June 14 Green Wt. of alfalfa lbs.	June 14 Per cent weeds	August 3 Total yield lbs.	August 3 Green Wt. of alfalfa lbs.	August 3 Per cent weeds	September 22 Total yield lbs.	September 22 Green Wt. of alfalfa lbs.	September 22 Per cent weeds
Three cuts on three cut schedule									
3a unsprayed	39	29.3	25.0	36	13.5	62.5	12	7.7	35.7
3b sprayed	40.5	18.2	45.0	39	16.8	57.0	12	9.0	24.8
6a unsprayed	59	38.4	35.0	29	6.3	78.3	12	9.5	20.3
6b sprayed	59	41.7	29.4	23	7.8	66.1	14	10.6	24.0

Plots and treatment	Cutting dates: July 7 Total yield lbs.	July 7 Green Wt. of alfalfa lbs.	July 7 Per cent weeds	August 18 Total yield lbs.	August 18 Green Wt. of alfalfa lbs.	August 18 Per cent weeds
Two cuts on two cut schedule						
2a unsprayed	46	41.4	10.0	30	28.5	5.2
2b sprayed	49	46.6	5.0	36	34.9	3.1
5a unsprayed	69	65.5	5.0	42	37.4	11.4
5b sprayed	76	72.2	5.0	47	43.3	8.3

When the plots were cut the material was weighed immediately. After weighing, the weeds were removed from a sample from each part of each plot, and the alfalfa weighed. In the tables, the figures giving the weight of alfalfa and per cent weeds were calculated from these data. During 1933 the same procedure was followed except that the sample containing only alfalfa was air-dried and again weighed. The ratio of the dry to the green weight of the alfalfa was derived in this way and is used in the table to show the difference in the succulence of the treated and untreated plots. Before each plot was cut ten stems were selected at random in each part of each plot to be cut and were severed at the ground, and the number of leafhopper feeding punctures in the fifth internode of each stem was counted under magnification. The yield data from the 1933 plots is presented in Table 2.

On the respective cutting dates all of each pair of plots was cut. For this reason conditions in each pair of plots were maintained exactly comparable. The spray used had no known fungicidal properties and no known effect upon plant growth. The different parts of each pair of plots were therefore exactly comparable in terms of leafhopper injury since only the leafhopper was controlled.

It had been observed that first growth alfalfa did not suffer from leafhopper injury in Wisconsin. As a result no work was started on the experiment until after the first growth of alfalfa had been cut. After this occurrence leafhopper numbers were determined on each part of each plot once each week. Infestations were determined by sweeping

TABLE 2. ALFALFA YIELD, SUCCULENCE, AND PER CENT WEEDS IN SECOND GROWTH FOLLOWING AN EARLY CUTTING COMPARED WITH A DEFERRED CUTTING AND THE RESULTS OF THE DIFFERENT TREATMENTS UPON LEAFHOPPER FEEDING ACTIVITIES AS SHOWN IN THE NUMBER OF FEEDING PUNCTURES. MADISON, WISC., 1933

Plots and treatment	Cutting dates: June 13 — Green Total yield lbs.	Green Alfalfa yield lbs.	Per cent weeds	Succulence*	Punctures	Cutting dates: August 4 — Green Total yield lbs.	Green Alfalfa yield lbs.	Per cent weeds	Succulence*	Punctures
Two cuts on three cut schedule										
1a unsprayed	78.5	56.7	27.7	.255	4	39.2	24.2	38.0	.358	193.6
1b sprayed	84.0	61.3	27.0	.322	8.5	38.2	34.6	19.9	.336	14.0
4a unsprayed	100.5	69.9	30.5	.493	3.6	51.8	30.2	41.9	.419	161.9
4b sprayed	102.0	56.3	44.8	.351	7.4	51.0	38.2	25.3	.340	19.7
Third cutting omitted. See text for reason										
	Cutting dates: June 27					August 19				
Two cuts on two cut schedule										
2a unsprayed	52.6	40.1	23.8	.444	11.1	41.8	30.2	27.8	.337	10.2
2b sprayed	53.1	44.5	16.3	.448	12.6	42.6	38.0	10.9	.310	5.6
5a unsprayed	75.6	61.7	18.4	.403	9.3	53.8	47.1	12.5	.332	14.7
5b sprayed	81.1	70.8	12.7	.497	7.4	54.0	48.9	9.5	.304	8.7

*—Succulence figure = ratio dry to green weight.

the plot with a net five times. No one spot was swept the second time between cuttings. In 1933, the full contents of the net after sweeping was removed to the laboratory and the number of adults and nymphs collected were recorded separately. The leafhopper catch was not divided in this way during 1932. Since the treated part of plot 1 and the treated part of plot 4 are exactly comparable, adults and nymphs collected in the two parts on the different dates were totaled and recorded respectively in separate columns. The same procedure was followed in the untreated portions of plots 1 and 4, as well as in the treated and untreated parts of 2 and 5. The results of these collections are given in Table 3.

DISCUSSION.—Infestation data collected during 1932 did not distinguish between adults and nymphs. Since this information has been found to be essential in explaining results in this experiment, these data were not included. It is also true that the yield records of 1932 given in

TABLE 3. COMPARATIVE RESULTS OF DEFERRED CUTTING AND SPRAYING FOR THE CONTROL OF THE ALFALFA LEAFHOPPER. MADISON, WIS., 1933

Date	Two cuts on a three cut schedule				Two cuts on a two cut schedule			
	Plots 1a and 4a unsprayed		Plots 1b and 4b sprayed		Plots 2a and 5a unsprayed		Plots 2b and 5b sprayed	
	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults
				First growth				
June 6....	0	10	0	8	0	6	0	9
June 13...	0*	41*	0*	25*	0	12	0	16
June 20...	—	—	—	—	5	132	1	111
June 27...	—	—	—	—	10*	62*	1*	139*
				Second growth				
June 20...	§	§	§	§	—	—	—	—
June 27...	1	152	0	107	—	—	—	—
July 4....	3	44	12	46	6	4	0	4
July 11...	836	91	219	55	24	47	8	58
July 18...	754	296	1	43	4	42	0	52
July 25...	99	540	9	17	12	169	16	25
Aug. 1....	62†	229†	2†	113†	28	206	7	127
Aug. 8....	—	—	—	—	32	164	2	102
Aug. 15...	—	—	—	—	60‡	95‡	2‡	58‡
				Third growth				
Aug. 8....	§	§	§	§	—	—	—	—
Aug. 15...	2	4	0	3	—	—	—	—
Aug. 22...	0	15	0	15	§	§	§	§
Aug. 29...	0	33	0	18	1	0	0	3
Sept. 5....	0	12	0	8	0	9	0	13
Sept. 12..	0	11	1	8	1	7	0	10
Sept. 19..	5	7	0	4	0	5	0	3

*Cut after sweeping on this date.
†Cut August 3.
‡Cut August 19.
§Too short for sweeping.

Table 1 may not be entirely comparable with those of 1933 because Bordeaux mixture through its fungicidal properties may have controlled some fungous parasites of the plant in addition to the leafhopper. These data are presented, however, because of the similarity in the results as compared with those obtained in 1933. Plots 1 and 4, cut once in 1932, demonstrated nothing of interest in this instance and are omitted.

At the beginning of the 1933 season it was quite apparent that plots 3 and 6 could not be used for further experimentation in this connection. The Bordeaux treated areas of plots 3 and 6 contained a fair stand of alfalfa but the untreated areas, what remained after the previous summer's treatment, had been almost entirely winter-killed and weeds remained. While it is true that 3b and 6b may have owed their preservation to the fungicidal as well as the insecticidal properties of the Bordeaux, it is also true that 3a and 6a were unable to survive a heavy infestation of leafhoppers and cutting three times a year. In this instance it is quite permissible to attribute the success of 3b and 6b to the effect of the Bor-

deaux mixture since the only difference in the manipulation of 3b and 6b as compared with 3a and 6a lay in the fact that only the former were sprayed with the Bordeaux.

When it was observed that plots 3 and 6 were no longer available for experimentation, plots 1 and 4 were used as three-cutting plots. Plots 2 and 5 had already been used as two-cutting plots and since alfalfa fields are seldom if ever cut only once a year in Wisconsin it was decided to discontinue the single cutting experiment and to utilize plots 1 and 4 in the three-cutting schedule. It will be noticed that plots 1 and 4, while started on a three-cutting schedule during 1933, were in fact cut but twice. It was quite obvious that these plots would be unable to survive winter conditions if cut the third time. Since it was desired to experiment further along these lines with these plots the third growth of alfalfa was not removed.

Tables 1 and 2 are very similar in as far as data common to both are concerned. That the first growth of alfalfa in Wisconsin is not seriously affected by leafhoppers was quite evident. There was no appreciable amount of yellowing in any part of any plot. The results of the second growth are very different. The effect of the leafhopper feeding influenced the results markedly. During 1933 when more complete data were taken, plots 1 and 4, in the second growth, show that the leafhopper feeding influenced the plots in many ways. In the untreated plots, where the activities of the leafhoppers were not hampered in any way, less alfalfa was produced, the alfalfa was less succulent, and more weeds occurred. These differences are present but to a markedly minor degree in the second growth of the plots cut on the two-cutting schedule. That the results of the leafhoppers feeding are responsible for the differences between the treated and untreated plots as well as between plots 1 and 4 as compared with plots 2 and 5 at the second cutting is further demonstrated by the record of the feeding punctures as shown in Table 2. In each instance the number of feeding punctures is correlated with the number of leafhoppers present, and also with succulence, yield, and amount of weeds present. All of these conditions obtain, but to a markedly minor degree, in plots 2 and 5 which were cut on the two-cutting schedule.

No attempt was made to determine quantitatively the relative amount of yellowing in the different parts of the different plots. Until the first cutting little yellowing was observed in any of the plots. The untreated parts of plots 1 and 4 were completely yellowed in the second growth. The difference in appearance between the treated and untreated parts of plot 1 are easily seen in the Plate. There was little observable differ-

ence betwen the two parts of plots 2 and 5 in the second growth. Yellowing was not serious in any of the plots after the second cutting.

Data presented in these tables indicate that in this experiment, weeds quickly appeared in the untreated parts of plots 1 and 4 in the second growth. It is assumed that inasmuch as the alfalfa in the untreated parts was stunted and retarded by the excessive leafhopper feeding, weeds were allowed to grow. The more vigorous alfalfa in the treated plots appears to have inhibited the growth of the weeds. This latter condition apparently obtained in both the treated and untreated parts of plots 2 and 5 in the second growth. Although the treated parts of plots 2 and 5 contained fewer weeds and the alfalfa made a more vigorous succulent growth, untreated parts, in the presence of the relatively light infestation of leafhoppers, were still able to make a very satisfactory growth as compared to similar parts of plots 1 and 4.

In the second growth, while it is quite obvious that controlling the leafhoppers in the treated plots decidedly influenced the yield of alfalfa, weeds present, succulence and number of feeding punctures as compared with the untreated parts, it is also quite obvious that the untreated parts of plots 2 and 5 suffered much less from leafhopper feeding than the untreated parts of plots 1 and 4. Despite the fact that they had all been given exactly the same spray treatment, the treated parts of plots 2 and 5 suffered less from leafhopper feeding than the treated parts of plots 1 and 4. Since the spray used in this instance has no known fungicidal properties and contains no plant nutrients which might affect the growth of alfalfa, it seems quite permissible to assume that the differences in yields in the treated portion of the two plots as compared with the untreated portions may be entirely attributed to the effect of the leafhopper activities in the untreated portion. The untreated portion of the plots are exactly comparable to the treated portion in every instance except that insects with sucking mouthparts were to a large extent destroyed in the treated parts. With the exception of a few aphids and tarnished plant bugs, there were no insects with haustellate mouthparts in the plots. During this period, no alfalfa eating insects were taken in the insect collections. With only the leafhoppers eliminated in the treated portions of the plots, differences between these portions and the untreated portions may be ascribed legitimately to the leafhopper activities in the different untreated portions.

Data presented in Table 3 suggests at least, why the first growth of alfalfa suffers little from leafhopper injury as compared with the second growth. Until the first growth of alfalfa was removed there were relatively few leafhoppers present.

The unsprayed part of plot 1 is shown in the right center. Its stunted, yellowed, dry, condition contrasts strongly with the tall, vigorous, succulent, unyellowed, sprayed portion which is contiguous to it upon the left. Madison, Wis. 1933.

It is clearly indicated that, in this instance, second growth alfalfa following cutting about the middle of June suffered very severely from leafhopper injury as compared with second growth alfalfa following cutting late in June (Table 2). An examination of Table 3 indicates that either one of two conditions were responsible for the slight damage done to plots 2 and 5 while a single condition probably caused the severe injury to plots 1 and 4. In the untreated parts of 1 and 4 as shown in Table 3, no nymphs were collected until June 27. Two weeks later, nymphs appeared in great numbers. This could only mean that at some time after June 13 and previous to July 11, great numbers of leafhopper eggs had been laid in the second growth alfalfa also that, at the time plots 1 and 4 were cut, the great majority of leafhoppers must have been fully mature and the females unspent. If the great majority of the leafhoppers present on the plots at the time of cutting had been nymphs the infestation would have been destroyed when the relatively immobile nymphs perished upon the bare field. The infestation would also have been destroyed if the females had laid their full complements of eggs which would have been removed from the field with the hay. It may therefore be assumed that at the date of cutting the great majority of the leafhoppers in plots 1 and 4 were adults which left the bare field when the alfalfa was removed but returned to lay their eggs within and to feed upon the tender young plants of the second growth. Leafhopper collections made from plots 2 and 5 support this theory. These plots were not cut until two weeks after plots 1 and 4. During this time, most of the female adult leafhoppers present must have laid nearly if not entirely their full complements of eggs. Whether these eggs were removed when plots 2 and 5 were cut or whether the eggs hatched before these plots were cut and the ensuing young perished upon the bare field after the alfalfa was removed is not definitely shown by these data. It is quite apparent, however, that one of these two conditions obtained for nymphs did not appear in plots 2 and 5 in numbers which even approximate those in 1 and 4 during the similar period. Cutting and removing the vegetative growth from plots 2 and 5 at the date indicated had the salutary effect of destroying the leafhopper infestation by eliminating the insect in one phase of the life cycle. It had not been observed that potato leafhopper nymphs migrate extensively. Table 3 indicates that the nymphs do not migrate far for, if they commonly migrated it seems that they would have occurred in greater numbers in the unsprayed parts of plots 2 and 5. Graber and Sprague[3] observed that if the first alfalfa cutting is deferred until

[3] "Alfalfa Yellows", Graber, L. F., and Sprague, V. G. Science. Vol. 78, No. 2026, p. 385.

the field shows abundant blossoming, the major portion of the leafhopper eggs will be removed from the field in the hay.

These data also indicate that the heavy leafhopper infestation in the second growth of plots 1 and 4 suffered the same fate, when alfalfa was cut, as that of 2 and 5 in the first cutting of those plots. Plots 1 and 4 were heavily infested with adult leafhoppers on the first of August. There were also many nymphs. After the plots were cut on the 8th of August, almost no nymphs and very few adults were collected during the remainder of the season. The egg and immature phases of the leafhoppers were destroyed apparently at cutting. The presence of adults subsequent to cutting may easily be accounted for by migration. In plots 2 and 5 the leafhoppers appear to have been destroyed in the nymphal phase when the alfalfa was removed on August 19. There was no general diminution of leafhopper numbers at this time since on, September 1 adults and nymphs were very abundant upon a nearby alfalfa field which was being permitted to produce seed and had not been cut the second time.

SUMMARY.—These data indicate that alfalfa cuttings may be so synchronized with the life cycle of the leafhoppers as to suppress the leafhopper infestation by destroying a large part of either the egg or nymphal stage. It is also shown that, in this instance, controlling the insect either by cutting the host at certain times or by the use of chemicals permitted the alfalfa to make a more normal growth and that the unhampered growth of the alfalfa tended toward the suppression of weeds. It was also shown that, in this instance, the destruction of the leafhopper infestation by cutting schedules properly synchronized with the vulnerable stages of the insects life history was sufficient to produce a satisfactory growth of alfalfa in the absence of all other leafhopper control measures.

THE USE OF OIL IN GRASSHOPPER BAITS

A Preliminary Report

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Poisoning with bran-mash bait is the best known method of grasshopper control, but it is by no means perfect. Poisoned-bran mash made with the usual ingredients of bran, poison, molasses, and water is most effective against grasshoppers when scattered so that it will be moist and attractive during that part of the day when maximum feeding is taking place. Feeding is largely controlled by temperature, and heavy feeding on bait is usually confined to a few hours each morning. When broadcast on dry ground, ordinary bait soon becomes dry and hard and any that is not eaten immediately is largely wasted unless later moistened by dews or light rains. This waste of bait and the short period during each day in which it can be effectively scattered are two serious obstacles to economical and effective grasshopper control. It was believed that the substitution of oil for both molasses and water in the standard bait might partly overcome these obstacles. Comparisons of ordinary poisoned-bran mash with oil bait in laboratory and field tests are presented.

LABORATORY EXPERIMENTS.—Palm oil, coconut oil, highly refined heavy and light medicinal mineral oils, and an inexpensive low-grade lubricating oil having a viscosity of 20 (S. A. E. rating) were used in initial tests. Palm oil and coconut oil were selected for their nondrying characteristics, their low cost, and because it was believed that vegetable oils might be more attractive to grasshoppers than mineral oils. Highly refined mineral oils were used because they were odorless and without pronounced taste; low-grade lubricating oil was tried because of its low cost and availability.

Preliminary mechanical tests indicated that oil used at the rate of 2 gallons to 100 pounds of dry bran was approximately the smallest quantity that would keep the individual flakes of bran in an oily condition for at least a week after exposure to high temperatures and low humidity. An exception to this was the refined heavy mineral oil, which was used at the rate of 1 gallon to 100 pounds of bran. Barium fluosilicate was used as the killing agent. Oil baits were compared with a bait containing 2 gallons of cane molasses and 10 gallons of water to 100 pounds of dry bran.

Comparisons of baits were made by the following method: Grass-

hoppers were placed in screen cages, 1 by 1 by 1 foot, in which freshly sprouted wheat was available at all times. The grasshoppers used were a mixture of early-instar nymphs of *Melanoplus differentialis* Thos., *M. bivittatus* Say, and *Camnula pellucida* Scudd. which had been hatched in the laboratory and reared on sprouted wheat. From 75 to 100 were placed in each cage and kept in a heated room where the temperature was favorable for feeding throughout the day. One-fifth gram (dry weight) of the bait to be tested was scattered uniformly over the wooden floor of a single cage. This was at the rate of 20 pounds per acre. As many cages were used at one time as there were baits to be tested. Dead grasshoppers were counted and removed 24, 48, and 72 hours after the baits had been placed in the cages. At the end of the 72-hour period those remaining alive were also counted. The total number killed in each cage during the 3-day period divided by the total number of grasshoppers used was taken as the percentage of kill.

The results of the experiments treated statistically are shown in Table 1.

TABLE 1. AVERAGE PERCENTAGES OF KILL OBTAINED WITH OIL GRASSHOPPER BAITS AS COMPARED WITH A NON-OIL BAIT IN LABORATORY TESTS DURING MARCH 1933. ALL TESTS WERE REPEATED THREE TIMES. (ELIMINATION TABLE, VARIANCE METHOD)

Bait*	Average kill (per cent)	Diff. (per cent)	Diff./P.E.
Cane molasses 2 gals., water 10 gals.	85.8±2.26		
Palm oil 2 gals.	84.3±2.22	1.5±3.17	0.47
Refined heavy mineral oil 1 gal.	81.5±2.14	4.3±3.11	1.38
Refined light mineral oil 2 gals.	81.5±2.14	4.3±3.11	1.38
Low-grade lubricating oil 2 gals.	77.4±2.03	8.4±3.04	2.76
Coconut oil 2 gals.	52.9±1.39	32.9±2.65	12.41
Check (no treatment)	4.4±0.11	81.4±2.26	36.02

*Basic formula: Bran 100 pounds, barium fluosilicate 4 pounds.

There was no significant difference (diff./P.E. = 3 or more) between any of the first five baits. Palm oil, refined mineral oil, and low-grade lubricating oil baits were all nearly as effective as the molasses-water bait. Neither of the vegetable oils, nor of the refined mineral oils, was outstandingly better than the low-grade lubricating oil. The latter, because of low cost and availability, was selected for field tests.

FIELD EXPERIMENTS.—During the summer of 1933 further work with oil baits was carried on under field conditions in North Dakota at Dickinson and Mohall. In the work at Dickinson, R. L. Shotwell and several assistants used 1½ tons of oil baits in detailed plot and cage experiments and in practical control in saving farm crops.

One series of plot and cage experiments was planned to determine the relative kills by oil and non-oil baits on each of the first 5 days of

feeding. Baits were scattered on 1-acre plots at the rate of 10 pounds (dry weight) per acre. Grasshoppers were collected from the treated plots 3 hours after the bait was put out and each day thereafter for 4 days. Daily percentages of mortality for individual plots were obtained

TABLE 2. AVERAGE PERCENTAGES OF KILL OBTAINED WITH OIL AND NON-OIL GRASSHOPPER BAITS FOR EACH OF THE FIRST 5 DAYS OF FEEDING ON ONE APPLICATION OF BAIT IN FIELD EXPERIMENTS AT DICKINSON, N. DAK. ALL TESTS WERE REPEATED SIX TIMES. (ELIMINATION TABLE, VARIANCE METHOD)

Bait*	Average kill per cent	Diff. Per cent	Diff./P.E.
First day			
Oil and sodium fluosilicate	95.2±3.57		
Oil and white arsenic	85.4±3.20	9.8±4.79	2.04
Cane molasses, water, and white arsenic	77.8±2.92	17.4±4.61	3.77
Cane molasses, water, and sodium fluosilicate	75.5±2.83	19.7±4.55	4.33
Check	35.5±1.33	59.7±3.80	15.71
Second day			
Oil and sodium fluosilicate	85.6±2.17		
Oil and white arsenic	81.3±2.06	4.3±2.99	1.44
Cane molasses, water, and sodium fluosilicate	72.7±1.84	12.9±2.84	4.54
Cane molasses, water, and white arsenic	72.6±1.84	13.0±2.84	4.58
Check	36.0±0.92	49.6±2.36	21.02
Third day			
Oil and sodium fluosilicate	80.8±5.51		
Oil and white arsenic	64.6±4.40	16.2±7.05	2.30
Cane molasses, water, and white arsenic	56.9±3.88	23.9±6.74	3.55
Cane molasses, water, and sodium fluosilicate	51.9±3.54	28.9±6.55	4.41
Check	38.2±2.60	42.6±6.09	6.99
Fourth day			
Oil and sodium fluosilicate	70.5±5.61		
Oil and white arsenic	60.0±4.78	10.5±7.37	1.42
Cane molasses, water, and sodium fluosilicate	55.6±4.42	14.9±7.14	2.09
Cane molasses, water, and white arsenic	50.3±4.00	20.2±6.89	2.93
Check	40.3±3.21	30.2±6.46	4.67
Fifth day			
Oil and sodium fluosilicate	75.1±4.60		
Oil and white arsenic	65.5±4.01	9.6±6.10	1.57
Cane molasses, water, and sodium fluosilicate	48.8±2.99	26.3±5.49	4.79
Cane molasses, water, and white arsenic	48.6±2.97	26.5±5.47	4.84
Check	41.8±2.56	33.3±5.26	6.33

*The quantities of bait ingredients per 100 pounds of dry bran were as follows: Sodium fluosilicate 4 pounds, white arsenic 5 pounds, oil 2 gallons, cane molasses 2 gallons, and water 10 gallons.

by holding each collection of grasshoppers for 3 days in a screened cage containing green food. A low-grade lubricating oil having a viscosity of 40 (S. A. E. rating) was used at the rate of 2 gallons to 100 pounds of dry bran. White arsenic and sodium fluosilicate were used as killing agents. The experiment was repeated six times during the period from June 25 to July 15. The plots used were very heavily infested with *Melanoplus mexicanus* and *M. bivittatus* in late instar and early adult stages and were so located that grasshoppers were moving into them daily from adjacent unpoisoned land. The results of the experiments treated statistically are shown in Table 2.

Each day the oil baits gave higher kills than non-oil baits, and the differences in most cases were significant. That the killing effect of the oil baits was also longer sustained is shown by the differences in effectiveness on the first and fifth days after the bait was scattered. The sodium fluosilicate-oil bait decreased 21.1 per cent while the sodium fluosilicate-molasses-water bait decreased 35.4 per cent. White arsenic-oil decreased 23.3 per cent, while the white arsenic-molasses-water bait decreased 37.5 per cent.

TABLE 3. AVERAGE PERCENTAGES OF KILL OBTAINED WITH OIL AND NON-OIL GRASSHOPPER BAITS AFTER 1 DAY'S FEEDING IN FIELD TESTS AT DICKINSON, N. DAK. ALL TESTS WERE REPEATED 13 TIMES. (ELIMINATION TABLE, VARIANCE METHOD)

Bait*	Average kill (per cent)	Diff. (per cent)	Diff./P.E.
White arsenic and oil	78.7±2.38		
Dry sodium arsenite, amyl acetate, and water	77.7±2.35	1.0±3.34	0.30
Dry sodium arsenite, cane molasses, and water	76.6±2.31	2.1±3.31	0.63
Sodium fluosilicate and oil	75.0±2.26	3.7±3.28	1.13
Barium fluosilicate and oil	72.4±2.19	6.3±3.23	1.95
Check	15.4±0.46	63.3±2.42	26.16

*The quantities of bait ingredients per 100 pounds of dry bran were as follows: White arsenic 5 pounds, dry sodium arsenite 2½ pounds, sodium fluosilicate 4 pounds, barium fluosilicate 4 pounds, oil 2 gallons, cane molasses 1½ gallons, amyl acetate 3 ounces, and water 10 gallons.

In a second series of cage and plot tests at Dickinson, oil and non-oil baits were compared on a basis of 1-day kills only. The results are shown in Table 3.

In this experiment there was no significant difference between oil and non-oil baits.

R. L. Shotwell and his assistants also compared oil and non-oil baits as they would be used in ordinary farm practice in saving crops. Ten comparisons were made in which each bait was scattered over areas ranging in size from 1 to 5 acres. Treated areas were examined each day for

5 days after application of the bait and estimates were made of the reduction in grasshopper populations. In 9 out of the 10 comparisons oil baits gave as good or better results than baits containing molasses and water.

Besides the work done under the immediate direction of R. L. Shotwell, a ton of oil bait was used during July and August in protecting crops on the experimental plots of the Dickinson substation from continued serious invasions of migratory grasshoppers. Bait containing 2 gallons of low-grade lubricating oil of 40 viscosity (S. A. E. rating) and 5 pounds of white arsenic to each 100 pounds of dry bran was prepared in large lots and kept on hand to be used when needed. It was scattered by ordinary farm labor without regard to time of day. The substation superintendent was well pleased with the results and expressed the opinion that the oil bait was fully as effective and more convenient to prepare and scatter than the usual molasses-water bait which had been used at the substation during June of the same year.

At Mohall, N. Dak., lack of equipment and assistance prevented the carrying out of detailed cage and plot experiments, but F. A. Morton was able to make 20 direct comparisons of oil and non-oil grasshopper baits under various field conditions.

In each case two areas a few rods apart having uniform infestations were selected. An oil bait was scattered on one area and a non-oil bait containing the same killing agent applied to the other. Kills were judged by counting the number of dead grasshoppers per square foot from 5 to 10 days after application of the bait. If neither bait produced an obviously greater kill than the other they were recorded as equal. In 10 comparisons using sodium fluosilicate as the killing agent, 6 were equal, 1 showed a greater kill for the oil bait, and 3 showed greater kills with molasses-water baits. In 10 comparisons where white arsenic was used, 3 were equal, 4 showed greater kills with oil, and 3 showed greater kills with the molasses-water baits. In only two comparisons were the oil baits decidedly inferior to the non-oil baits. These were when bait was scattered on extremely dry sod where the warrior grasshopper (*Camnula pellucida*) was massed in large numbers for egg laying. Under these conditions the baits containing molasses and water were eaten more readily and produced distinctly greater kills.

With one exception oil was used in the work at Mohall at the rate of 1½ gallons to each 100 pounds of dry bran. This was half a gallon less than the quantity used at Dickinson and may partly explain the slightly better results obtained with oil baits at the latter place. It is of interest to note that in the one instance at Mohall where bait containing 2 gallons of oil was used 25 acres of flax very heavily infested with the migratory

grasshopper (*Melanoplus mexicanus* Sauss.) was treated with excellent results. The oil used at Mohall was light lubricating oil having a viscosity of 10 (S. A. E. rating).

SOME ADVANTAGES OF OIL BAITS.—Preliminary results in the laboratory and under field conditions encourage the belief that oil can be substituted for both molasses and water in ordinary grasshopper baits without decreasing their immediate killing effect and that their effectiveness will be longer sustained when oil is used. Should future work corroborate these results, oil baits will have many advantages over the usual poisoned-bran mash containing molasses and water. Some of the more important advantages are as follows:

1. *Less bait is wasted.* Bran that has been wet either with water alone or with molasses and water becomes dry and hard shortly after it is scattered on hot, dry ground, and within an hour individual flakes of bran become less attractive to grasshoppers than flakes that have never been wetted. Even when great care is exercised in scattering wet bait, much of it sticks together in small lumps, and when care is not taken these lumps may be several inches in diameter. On drying they become a solid mass which cannot be eaten even by large grasshoppers and the material within them is wasted unless it happens to be softened by later rains. When baits made with oil are scattered, they separate into individual flakes of soft, oily bran, which remain in that condition for several days and can be easily eaten by even newly hatched grasshoppers. Unless ordinary bait is scattered just before or during the optimum feeding period, very little of it is eaten that day, and for the reasons noted above it loses much of its effectiveness during subsequent feeding periods. In ordinary farm practice the optimum feeding period is frequently not recognized, and in the past large quantities of poisoned-bran mash have been wasted because it was scattered at the wrong time. Even though oil baits are not scattered during the optimum feeding period, they remain attractive for several days and are readily eaten whenever optimum feeding conditions recur.

2. *The bait can be scattered during a longer period.* The short period of each day, usually not over 4 hours, during which ordinary grasshopper baits can be effectively applied hinders progress in all large-scale grasshopper campaigns. Individual farmers often find it impossible to scatter bait over all their infested fields in time to prevent serious damage to crops, and when crews of men are employed for scattering there is much loss of time because of the short period they can be worked each day. The use of oil baits, which can be scattered during any hour of the day without serious loss of effectiveness, will greatly decrease the time needed to

treat grasshopper-infested territory. In any large-scale grasshopper campaign this factor alone will greatly increase the chances of killing grasshoppers before serious damage to crops takes place.

3. *The bait can be stored without deterioration.* Ordinary grasshopper baits must be used within a few days after they are mixed, otherwise they ferment, mold, and cake. Considerable bait is often wasted when unexpected inclement weather makes it impossible to scatter bait that has already been mixed. Oil bait ready for field use can be stored for months without deteriorating. Large quantities can be prepared in advance and held ready for use at any time. In large campaigns this would obviate the necessity for double shifts, overtime hours, and the use of inexperienced labor at mixing plants when large quantities of bait were needed for immediate use.

4. *The bait can be transported and scattered with greater ease.* Only half as much weight of oil bait per acre is required as when baits containing water are used. This means that the use of oil baits would enable scattering crews to cover nearly twice as many acres without stopping for a fresh supply and the cost of transporting bait from central mixing stations to the localities where it was to be used would be greatly reduced. In airplane scattering, twice as much bait could be carried, which would cut in half the time lost in reloading. In every grasshopper campaign it is extremely difficult to train farmers and scattering crews to broadcast wet bait so that it will not fall in lumps that are dangerous to livestock and ineffective against grasshoppers. Oil baits separate into flakes even when scattered by inexperienced labor. It is also believed that oil baits will work better in mechanical spreaders than does the wet bait, but this point has not as yet been demonstrated in practice.

5. *Its cost is low.* Oils suitable for grasshopper baits can be purchased in car lots at 10 to 15 cents per gallon. The use of oil will not increase the cost of grasshopper bait and if transportation and scattering charges are figured the total cost of grasshopper control will be decreased.

Further work is needed to determine types and quantities of oil that will give best results in grasshopper baits. However, the results of one season's work indicate that oil baits are worthy of more extended tests and that in their use there is the possibility of more economical and effective grasshopper control.

MR. DAVIS: Could you give the formula you use and also the kind of oil?

MR. PARKER: The oil used in our summer's work was a low-grade lubricating oil, having the viscosity of 30 S. A. E. rating. The viscosity

probably is the main thing. Otherwise about the same grade of oil did not give quite as good results as one of higher viscosity. We used oil with white arsenic baits, sodium arsenate, barium and sodium fluosilicate; and two gallons of molasses and ten gallons of water to the hundred pounds of bran, where we used water. Of course, in the oil baits we simply mixed the poison and bran dry and then worked in two gallons of oil to 100 pounds of bran.

MR. HORSFALL: What were the results in using fluosilicate as compared with arsenate?

MR. PARKER: The results with sodium fluosilicate were very good. It kills much quicker than white arsenic. You get results in 24 hours. The total kill I think is about the same over a period of time with the psychological effect of killing them right now, which is well worth while. Barium silicate worked almost as well. That also kills very quickly.

MR. BILSING: Did you use sodium arsenate?

MR. PARKER: Yes, dry sodium arsenate in some of them. All of those poisons will kill grasshoppers in fine shape. We used poisons that we knew would kill them so we could compare poisons with and without the oil.

THREE YEARS WORK AGAINST GRASSHOPPERS IN MINNESOTA[1]

By A. G. RUGGLES

The last three or four years in Minnesota have contributed a larger grasshopper population than ever before in its history. Even the invasion of the Rocky Mountain Locust in the state in the 70's had not the destructive potentialities of this present outbreak.

The four maps of Minnesota accompanying this article show the infested grasshopper areas in the years indicated. It will be noted that in 1931 a comparatively small area was infested. It will be seen that the infestation reached its peak in 1932. In this year our control operations were brought into action and since then the infestation has been steadily reduced. During the three years under consideration,—1931, 1932, 1933,—the weather for grasshoppers has been ideal. Perhaps this state-

[1]Paper No. 291 of the Miscellaneous Journal Series of the Minnesota Agricultural Experiment Station.

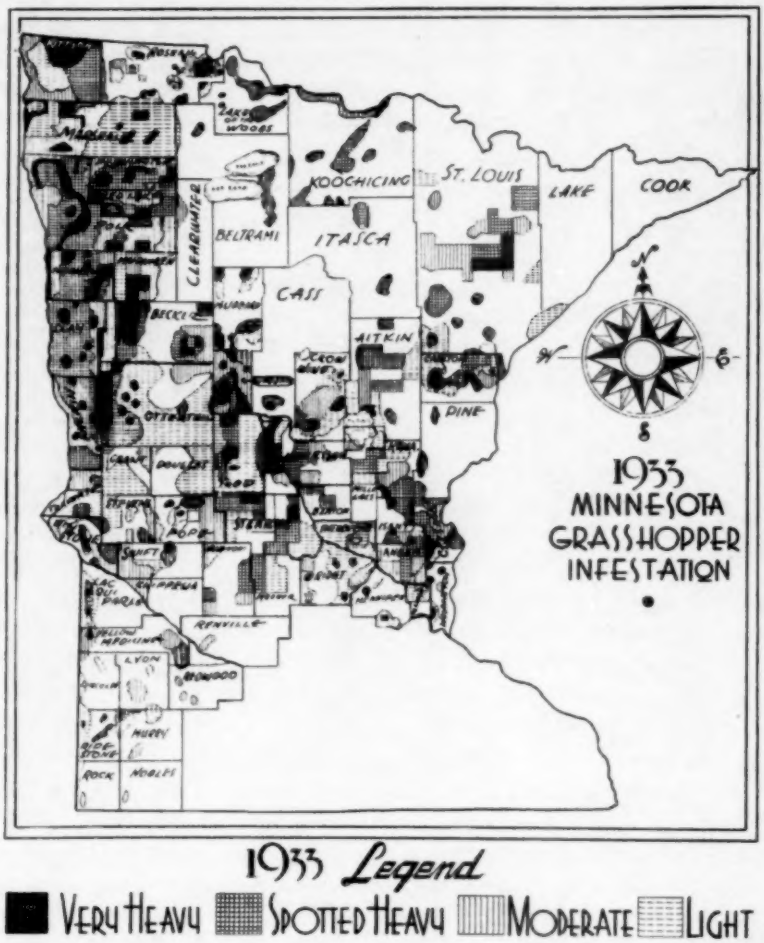
ment should be modified to the extent that in a few sections it was so dry that the grasshoppers could not find enough to eat. In Minnesota during these years the 'hoppers received no serious set back by nature.

In 1931 the growing season was upon us before the danger was realized. It was not until the second week of July in that year that control work was started. The first report came from Kittson county in the northwest corner of the state. Upon investigation it was found that the adjoining counties along the Red River, Marshall and Polk, were the most severely infested. Some of the other counties with spotted heavy infestation were

Pennington, Red Lake, Norman, Clay and Wilkin. A number of other counties had an abundance of grasshoppers in a few areas but these were the worst.

As the farmers in these areas were wholly unable to purchase the necessary ingredients for the poison bran bait and the counties had no authority to appropriate money for such work even if they wished, the matter was placed before the Minnesota State Executive Council. This council is made up of the Governor of the state, the Secretary of State, the Attorney General, the State Treasurer and the State Auditor. This

council has at its disposal certain funds for relief purposes. The council in 1931 granted $29,500.00 for the purchase of poison bran bait to be distributed to the farmers in the infested areas.



Even with such a late start it was proven very definitely and conclusively that if the poison bran could be applied properly a grasshopper attack of large proportions could be held in check. The farmers worked with in 1931 were sold to the idea of control and were enthusiastically behind a movement to protect the entire infested area.

Cooperating with the U. S. D. A. Bureau of Entomology an egg survey was made in the fall of 1931. The survey revealed that an extremely

heavy infestation was in store for 1932. A glance at the 1932 map shows the infested and non-infested areas. Beside the counties heavily infested in 1931 there were now to be added areas in Roseau, Koochiching, Beltrami, Ottertail, Stearns, Becker, Todd, Traverse, Mille Lacs and a

number of small infestations in several other counties. In all 55 counties were in the organization plan for that year. Each of these counties used quantities of bait. Certain counties in the southwestern part of the state were threatened, but due to timely rains there no damage was done to the crop by grasshoppers. The adjoining area in South Dakota was heavily infested with eggs but rains there also prevented any serious loss

that year. In all 3,665,265 acres were heavily infested in Minnesota, 1932.

The eggs hatched as per schedule. Our organization plans, however, had gone forward rapidly. Starting in February 1932 the farmers in the infested area had been warned of the danger and before the hatching season arrived every farmer in these districts was ready. Altogether in the year 1932 the State Executive Council appropriated $250,000.00 for the purchase and distribution of the poison bait; 11,324 tons bait were purchased and distributed. Great success was attained. At the end of the season in summing up the results it was found that even with farm prices at the low ebb, over $12,000,000.00 worth of crops were saved.

The egg survey for the fall of 1932 showed that the infested areas had been reduced to 528,828 acres. The extent of the trouble in the following season is shown by the 1933 map. It will be noted that a small infestation was building up in the eastern part of the state in St. Louis, Carlton, Pine, and Chisago counties. As the people in this area were somewhat luke warm in their program of control, the insects increased in population. However, before the end of the season they were all working vigorously and I think 1934 will see this infestation area under control.

In 1933 the State Executive Council allowed us to expend $55,000 for the purchase and distribution of grasshopper bait to counties; 1806 tons of bait were used and during 1933 there was no report of any appreciable crop loss from grasshoppers in any county in Minnesota.

The fall egg survery of 1933 shows that less than 280,000 acres are heavily infested with grasshopper eggs. The 1934 map shows the areas almost back to normal as far as grasshopper infestation is concerned, with the few relatively high infested spots in the eastern part.

The three years control campaign in Minnesota shows that if an outbreak of insects of this kind is gone at methodically and relentlessly thru proper organization to make control methods effective coupled with the proper expenditure of funds for control materials, success will be the result.

THE LIFE HISTORY AND CONTROL OF THE POTATO FLEA BEETLE, *EPITRIX CUCUMERIS* HARRIS, ON THE EASTERN SHORE OF VIRGINIA

By LAUREN D. ANDERSON, *Assistant Entomologist,* and HARRY G. WALKER, *Entomologist, Virginia Truck Experiment Station, Norfolk, Virginia*

The potato industry on the Eastern Shore of Virginia, one of the largest early potato growing sections in the United States, is being seriously threatened by the potato flea beetle, *Epitrix cucumeris* Harris. This insect has been on the increase on the Eastern Shore of Virginia for the last several years, and in the northern part of Accomac County has caused a 25 per cent reduction in yield as well as a reduction in quality the last two years.

In view of these facts, control and life history studies of this insect have been in progress the last two seasons at a temporary field laboratory of the Virginia Truck Experiment Station on the B. P. Paradee and D. F. Miles farms near New Church, Virginia.

LIFE HISTORY.—Egg laying cages were made by covering both ends of number 2 lamp chimneys with a double thickness of cheese cloth, fastening the cloth by means of a cord at the bottom and a rubber band at the top, facilitating its removal for the addition of fresh food. Disks of blotting paper were cut to a size that would fit into standard 100 x 15 mm Petri dishes and then the blotting paper was covered with a thin coat of fine black mud. These disks were then placed on moist soil and the lamp chimney cages placed on the disks. Beetles kept in these cages forced their ovipositors through the cheese cloth and laid eggs on the disk below. These disks were removed daily and placed in moist Petri dishes and the period of the egg stage determined. Care was taken to remove any eggs that stuck to the cheese cloth, thus preventing an error in egg records. As the eggs hatched, small pieces of potato were put in these Petri dish rearing cages and the newly hatched larvae entered them almost immediately, feeding there until full grown. At this stage the blotting paper disks were removed and several teaspoonfuls of moist soil were placed in the dish next to the tuber to afford material in which the larvae could pupate.

In the spring the overwintering adults come out of hibernation early and in 1933 were quite abundant in the field by May 1st, attacking the few plants that were up. Some of these beetles were collected and put in egg laying cages on May 12th, and life cycle studies started. Eggs were taken from these cages daily until June 2nd. The maximum egg

production occurred on May 21st. The length of the egg stage for some 1000 eggs examined was found to be from 5½ to 6½ days or an average of 6 days.

The tiny larvae, measuring 1 mm in length, are very delicate and difficult to handle, and as a result the different instars were not studied. However, the total length of the larval stage was found to be from 13 to 15 days or an average of 14 days. Full grown larvae were found in the field with their heads in the potato and the rest of the body supported by the soil. In the rearing cages very few larvae assumed this position due to abnormal environmental conditions.

The full grown larvae leave the tubers, build small earthen cells, and spend from 2 to 3 days in a quiescent prepupal stage before changing to pupae. The total prepupal and pupal stage was found to last from 11 to 13 days or an average of 12 days. The total life cycle was found to require from 29½ to 34½ days or an average of 32 days.

With a maximum egg production on or near May 21st, and an average life cycle of 32 days, adult beetles would occur in maximum abundance on or near June 22nd. This checks very closely with field conditions as the adult population in the field increased tremendously for several days after June 19th, and these beetles remained in the field until harvest time. Collections were made with a sweep net when the beetles were most abundant in the field in order to determine the approximate number present. About 600,000 beetles were collected from a half acre and since it appeared that not more than one-half of the beetles were caught, the population was estimated to be from two to two and a half million per acre. Adults were so numerous that they gave the tops of the plants a black appearance.

From a review of the life history it seems that protection for the potato plants is most needed early in the season until about May 25th and later when the new brood of adults appear after June 20th.

CONTROL.—Insecticide tests were conducted on two farms, with three tests of each material on each farm. These test plats consisted of three rows 45 feet long and all records were taken on the 40 feet located in the central portion of the middle row. Applications were made six times during the season, using a compressed hand sprayer, applying about 100 gallons of material to the acre, and a rotary hand duster applying from 30 to 50 pounds of dust to the acre.

The materials used and the results obtained are given in Table 1. A study of this table shows that out of the seven best yielding materials, five are bordeaux sprays, either commercial or homemade, in combination with calcium arsenate. The other two materials in the first seven

are more expensive than a bordeaux-calcium arsenate spray and as measured by these tests gave no marked significant differences in yield. The lead arsenate-Paris green-zinc sulphate-lime dust and also the lead arsenate-lime dust cost approximately four times as much as the bordeaux-calcium arsenate spray. The addition of Black Leaf 40 to the bordeaux-calcium arsenate spray gave a slight increase in yield, but not enough to pay for the additional cost of the material; however, if aphids are abundant it might be profitably added.

TABLE 1. RESULTS OBTAINED IN THE POTATO FLEA BEETLE EXPERIMENT IN 1933 GIVING THE INSECTICIDES AND PROPORTIONS USED AND THE YIELDS EXPRESSED IN BARRELS PER ACRE

Insecticide	Dilution	Paradee farm yield	Miles farm yield	Both farms average yield
Lead arsenate-lime dust	1–1	107.7	66.7	87.2
Calcium arsenate-Bordeaux-Bl. 40 spray	2–4–6–(1–400)–50	106.0	64.8	85.4
Calcium arsenate-Pyrox spray	2–7–50	102.5	68.3	85.4
Lead arsenate-Paris green-zinc sulfate-lime dust	(5–1) 1–(2.4–4)1	100.8	66.7	83.7
Calcium arsenate-Bordeaux spray	2–4–6–50	101.7	60.5	81.1
Calcium arsenate-Bordeaux spray-Derris dust	(2–4–6–50) (1–7)	105.0	56.4	80.7
Calcium arsenate-Oxobordeaux spray	4–4–50	90.5	66.6	78.5
Lead arsenate-zinc sulfate-lime spray	2–2–2–50	85.4	70.8	78.1
Calcium arsenate-zinc sulfate-lime dust	1–1–1	96.5	58.9	77.7
Calcium arsenate-lime dust	1–1	89.7	63.2	76.4
Calcium arsenate spray	2–50	88.8	60.5	74.7
Lead arsenate-Bordeaux spray	2–4–6–50	82.0	65.8	73.9
Copper-lime dust	1–4	86.3	61.5	73.9
Lead arsenate spray	2–50	90.5	55.5	73.0
Dutox-lime dust	1–3	91.5	53.8	72.6
Calcium arsenate-copper-lime dust	1–1–3	82.8	61.5	72.1
Bordeaux spray	4–6–50	85.4	58.0	71.7
Zinc arsenate spray	2–50	82.0	58.9	70.5
Lead arsenate-Paris green dust	5–1	83.7	55.5	69.6
Calcium arsenate-zinc sulfate-lime spray	2–2–2–50	81.1	53.0	67.0
Derris dust	1–3	78.6	53.8	66.2
Lime dust	Undilute	69.2	63.2	66.2
Super agricultural spray	1–200	77.7	53.0	65.4
Zinc sulfate-lime spray	2–2–50	72.5	58·0	65.3
Concentrated derris extract	1–400	73.5	55.5	64.5
Derris dust	1–7	76.8	50.4	63.6
Paris green-zinc sulfate-lime spray	1–2–2–50	73.5	43.5	58.5
Dutox-flour dust	1–3	71.7	45.3	58.5
Check		66.6	48.7	57.6
Dutox spray	2–50	63.4	48.6	56.0

The arsenicals alone as sprays gave fair results. The calcium arsenate gave the highest yield as compared to the other arsenicals with lead arsenate second, followed closely by zinc arsenate. In the dust form, the

lead arsenate-lime dust gave the best results of all of the treatments while the calcium arsenate-lime dust gave a very marked increase in yield over the checks. Paris green as a spray or dust caused a marked foliage burning resulting in a lower yield except when used in the lead arsenate-Paris green-zinc sulphate-lime dust where a smaller amount of Paris green was used.

In most cases tested the addition of zinc sulphate to the other materials gave a slight increase in yield.

Barium fluosilicate (Dutox) and sodium aluminum fluoride (Cryolite) caused a marked browning and curling of the leaves resulting in a decrease in yield. Cryolite injured the foliage so severely in 1932 that it was not included in the 1933 experiment. Although some injury occurred with the Dutox-lime dust, it was not as pronounced as with the Dutox spray and Dutox flour dust where the injury was so severe that any benefits derived from the control of the beetles was offset by the injury to the foliage. This burning was much more pronounced when the materials were applied during humid rainy weather.

Some striking results were obtained with Derris products, both in the spray and dust forms, when used on a small scale. Kills of better than 90 per cent were obtained in caged material when treated with a Derris dust containing 0.5 per cent rotenone, or with a concentrated Derris extract with 5 grams rotenone per 100 cc diluted 1 to 400. When these materials were used in the field, good kills were also observed, but permanent protection was not given and the beetles migrated in from surrounding unsprayed plats causing considerable injury.

In proving statistically the data given in Table 1, a combination of Student's and Fisher's methods was used. According to this method, odds of 20 to 1 that the increase in yield of one material over another is not due to chance alone, are significant. In order that the yield of one material may vary significantly from that of another, there must be a difference of 10.8 barrels per acre in the Paradee plats, 7.4 barrels per acre in the Miles plats, and 2.5 barrels per acre in the average of the two farms.

The Relation of Flea Beetle Injury to Yields.—The amount of flea bettle injury on the plants of the differently treated plats was estimated by counting the number of flea beetle feeding holes in the leaves. Five leaflets were taken from each of three plants in each plat, making a total of 15 for each plat and 45 for each treatment. Leaflets were pulled at random, one from each of the four sides, and one from the center of the top of each seventh plant. Samples were taken on May 25th and on June 24th to estimate the accumulative effect of treatment.

In one method the data used were from only the twenty treatments where no spray injury was noted during the period of the experiment. In the other the data for the entire experiment were utilized. The correlations are as follows: For the early count on May 26th, Rxy = — .68 ± .05 for the 20 treatments, and — .34 ± .07 for the entire series. In the later count made on June 24th, Rxy = — .73 ± .06 for the 20 treatments and — .30 ± .06 for the whole series.

This degree of negative correlation between flea beetle injury and yields for the 20 treatments indicates that flea beetle injury was an important factor in reducing the yield, and increases in yield were largely due to flea beetle control.

The relatively low degree of correlation for the entire experiment including the spray injured plants, shows clearly that spray injury was an important factor in affecting yield in certain plats and that it reduced the benefits derived from flea beetle control.

The higher degree of correlation obtained from the leaf counts made on June 25th indicates that later protection is more essential in regard to increase in yield, while early protection is more important in preventing tuber injury by the larvae.

STUDIES OF MILLIPED AND GNAT INJURIES TO POTATO TUBERS

By G. F. MacLeod and F. G. Butcher

Potato tubers in Western New York have been severely injured by the feeding activities of millipeds, (*Diploiulus londeninsis coeruloecinctus*) and fungus gnat larvae, (*Sciara* sp.). A survey of 312 fields in 15 counties at digging time in 1931 showed an average of 24 per cent of the tubers injured by these pests, and a similar survey in 1932 showed over 15 per cent of the tubers injured. In some cases as high as 97 per cent of the tubers have been injured by these organisms. Such injuries greatly decrease the market quality of tubers and result in serious losses to growers.

Experiments designed to reduce these milliped and gnat injuries have been conducted principally with the use of three materials, namely, sulphur at rates of from 150 to 600 pounds per acre, naphthalene at from 300 to 600 pounds per acre and tobacco dust at from 400 to 500 pounds per acre. All of these materials have been applied to the soil either by hand or with a grain drill, and then worked into the soil by harrowing previous to the planting of the potatoes. Data on the effectiveness of

the treatments were secured by counting the various injuries on adequate samples of tubers at digging time. A summary of all results thus obtained is presented in Table 1.

TABLE 1. RESULTS OF SOIL TREATMENTS TO REDUCE GNAT AND MILLIPED INJURIES TO POTATO TUBERS

Treatment	Number of experiments	Clean tubers (per cent)	Tubers injured by Gnats (per cent)	Tubers injured by Millipeds (per cent)
Sulphur	20	31.58	32.79	33.91
Untreated	—	24.17	40.14	42.14
Naphthalene	12	25.78	39.30	43.69
Untreated	—	20.82	46.65	46.35
Tobacco dust	7	30.98	24.41	21.59
Untreated	—	29.87	26.05	22.06

The data in Table 1 indicate that no practical control was obtained with any of these three treatments. The tobacco dust and naphthalene treatments show small reductions in the percentage of injured tubers and a correpondingly small increase in the percentage of clean tubers. While the figures from the sulphur treatments show a somewhat higher degree of effectiveness, the differences are neither statistically nor materially significant.

Gnat and milliped injuries to potato tubers seemed closely associated with the occurrence of potato scab. The relationships of potato scab to soil acidity are known and it was therefore not surprising to find gnat and milliped injury apparently correlated with soil pH. Sulphur was used to acidify the soil in an attempt to reduce the injuries by gnats and millipeds.

A study of the individual experiments where sulphur was used and from which the summary figures were obtained presents interesting inconsistencies. There were several cases in which significant increases in the percentage of clean tubers were obtained and other cases in which there were practically no benefits derived from treatments. Table 2 shows some of these cases.

TABLE 2. RESULTS OF SOME EXPERIMENTS WITH SULPHUR TO REDUCE GNAT AND MILLIPED INJURIES TO POTATO TUBERS

Exp. No.	Rate acre pounds	Increases (+) or decreases (—) of treatments over check: clean	injuries gnat (per cent)	injuries milliped (per cent)	pH of treated plats: start	finish	change
1	150	+ 7.47	—11.30	—12.87	6.34	5.22	—1.12
2	400	+29.00	—25.00	—13.00	5.56	4.76	—0.80
3	600	+25.06	—40.80	—20.20	5.30	4.33	—0.97
4	400	+ 0.73	—3.18	—3.46	5.27	5.32	+0.05
5	400	+1.36	—4.09	—2.27	5.38	5.25	—0.13
6	400	+0.17	+0.83	—2.66	5.96	5.25	—0.71
7	300	+2.60	—0.40	—5.80	5.75	5.53	—0.22

The first three experiments in the above table were conducted by the senior author in Steuben County, New York, while the remaining experiments shown were conducted in Monroe County, New York by the junior author. It is evident that in the Steuben experiments more substantial reductions in injuries were secured than in Monroe County and this is true for all of the experiments carried on in the two regions. In experiment 1, (Table 2) a small reduction in injuries is evident from the treatment, together with a large reduction in the hydrogen-ion concentration of the soil. However, the final pH value is well within the range of occurrence of considerable injury. The original pH value was so high that the small amount of sulphur applied was not sufficient to reduce the pH value below this range of injury. In experiments 2 and 3 the original pH values were low enough so that the larger amounts of sulphur applied did reduce the hydrogen-ion concentrations to the lower limits of injury, and there is evident a correspondingly greater effectiveness.

The Monroe County experiments show but very little control, and small decreases in the soil hydrogen-ion concentration. Although the original pH values are not extremely high, there are no cases in which the sulphur reduced these values below the range of injuries. Where the pH was reduced to a point comparable to that in experiment 1, there was no evident corresponding reduction of injuries. Inasmuch as the manner of conducting the experiments in the two counties has been as similar as possible, and since there has been no appreciable differences in the populations of the organisms concerned, it would seem that the different results obtained in the two areas may be due to certain unknown soil factors. At present no information is available as to what these unknown factors may be, nor any method of readily ascertaining their presence or absence.

SUMMARY.—Of the materials tested sulphur gave the largest reduction in proportion of injuries but none of the materials used gave satisfactory commercial control of the pests. It seems evident that under certain conditions sulphur materially reduced gnat and milliped injuries to potato tubers, provided the hydrogen-ion concentration of the soil was reduced to below pH 5.00 However, the degree of effectiveness in preventing tuber injuries by gnats and millipeds by the use of sulphur fluctuated widely, probably because of regional soil differences.

FURTHER STUDIES ON THE CONTROL OF THE ONION THRIPS

By FRANK B. MAUGHAN, *Ithaca, New York*

In a previous paper (Jour. Eco. Ent. 26: 143–147, 1933) the writer reported on the use of crude chipped naphthalene for controlling the onion thrips, *Thrips tabaci* Lindeman. During the past season this work was continued using crude chipped naphthalene in combination with various materials as dusts. The experiments were conducted on muck land onion fields near Goshen, in Orange County, New York. Some of the results are of interest since they represent the possibility of further economy in control methods for this pest.

EXPERIMENTAL PROCEDURE.—The materials used in these experiments were as follows:

1. *Naphthalene-Pyrethrum dust.*
   - Crude chipped naphthalene — 40 pounds
   - Pyrethrum (Alcoholic extract) — 25 pounds
   - Talc powder (Loomis Talc) — 35 pounds
2. *Naphthalene dust.*
   - Crude chipped naphthalene — 40 pounds
   - Hydrated lime — 60 pounds
3. *Nicotine dust.*
   - Niagara Spray Chemical Company — 4 per cent Nicotine
4. *Crude chipped naphthalene.*
   - Barrett Company

The crude naphthalene used in treatments one and two, was crushed and sifted through a fine screen, mixed with talc powder or hydrated lime and allowed to stand in an air tight container for twenty-four hours before using. The pyrethrum was added to the dust mixtures just previous to the time of application. The nicotine dust, a commercial product, was purchased ready for use. The naphthalene dusts were applied early in the morning when the plants were wet with dew. The nicotine dust was applied during the day when the temperatures were 75 degrees F. or higher. In experiment number four, the undiluted crude chipped naphthalene was applied in the afternoon when the temperatures ranged around 80 degrees. Each plat received five applications during the critical period of infestation, from July first to August fifth.

The dust treatments were applied with a Niagara rotary hand duster or with a power duster attached to a Bolen's tractor. The crude chipped

naphthalene was applied by hand, directly along the row, with an attempt to deposit as much naphthalene as possible on the plants. The same material was broadcast over a number of rows at a time.

In laying out the plats the strip row method was followed. Each plat consisted of four rows with the exception of those in experiment number four, where each plat consisted of eight rows. The plats were all replicated a number of times to compensate for the variations in soil, degrees of infestation and other ecological factors that might arise as the season progressed. Approximately one and one-half acres of onions were treated in each experiment.

The effectiveness of each treatment in controlling the onion thrips was determined after each application, in the following manner. Twenty-five plants were counted in every plat, the number of live thrips remaining on each plant being recorded. Definite counting-areas were established across all plats, paralleling each other, so that the data obtained would be statistically comparable.

The same general procedure was followed in obtaining the yield data. Five areas of onions, each fifty feet long and four rows wide were harvested from each plat. The onions from each of these areas were weighed, the figures obtained being converted into bushels per acre.

DISCUSSION OF RESULTS.—From the results obtained it is apparent that all of the materials used substantially reduced the number of thrips on the onion plants. (Tables 1–4.) It is also shown that these reductions in the thrips population are definitely correlated with the increased yields.

A comparison of the various treatments showed several differences. It should be pointed out, however, that none of these differences are statistically significant, except in the case of increased effectiveness of the naphthalene combinations over the nicotine dust. (Tables 1–2). Further experiments are needed to determine whether or not the addition of pyrethrum to the naphthalene dust will prove to be of practical benefit. Although the plats treated with nicotine dust, gave a significant increase in bushels of onions per acre over the untreated plats, the cost of the materials practically prohibits its use.

Crude naphthalene applied undiluted by hand directly to the plants consistently produced higher yields than the broadcast method of applying the same material. (Table 4.)

A consideration of the comparative merits of undiluted crude chipped naphthalene applied by hand over naphthalene dust mixtures, as applied by machinery is of practical interest. The total cost of applying the naphthalene-hydrated lime dust is much lower than the cost of applying

TABLE 1. COMPARATIVE NUMBER OF THRIPS PER PLANT AND RESULTANT INCREASES IN YIELD OF ONIONS

Treatments	Average number of thrips per plant	Total yields (bushels per acre)	Increase bushels per acre over check
Experiment 1			
Naphthalene pyrethrum	14	599.92	94.64
Naphthalene dust	16	581.36	76.08
Nicotine dust	25	564.53	59.25
Check	179	505.28	
Significant difference	68		29
Experiment 2			
Naphthalene pyrethrum	57	516.29	56.30
Naphthalene dust	52	514.98	54.99
Nicotine dust	90	492.49	32.50
Check	275	459.99	
Significant difference	19		15

TABLE 2. COMPARATIVE NUMBER OF THRIPS PER PLANT AND RESULTANT INCREASES IN YIELD OF ONIONS

Treatments	Average number of thrips per plant	Total yields (bushels per acre)	Increase bushels per acre over check
Experiment 3			
Naphthalene dust	42	546.79	81.32
Check	255	465.47	
Significant difference	34		29

TABLE 3. COMPARATIVE NUMBER OF THRIPS PER PLANT AND RESULTANT INCREASES IN YIELD OF ONIONS

(Undiluted crude naphthalene)

Treatments	Average number of thrips per plant	Total yields (bushels per acre)	Increase bushels per acre over check
Naphthalene on the row	12	543.59	62.08
Naphthalene broadcast	21	536.87	55.36
Check	165	481.51	
Significant difference	30		27

SUMMARY TABLE. RELATIVE COSTS AND RESULTS OBTAINED WITH NAPHTHALENE TREATMENTS FOR THE CONTROL OF THE ONION THRIPS

Treatments	Pounds per acre (one application)	Total cost of material (in dollars)	Increases over check (bu. per acre)	Average number of thrips per plant
Naphthalene pyrethrum	200	33.90	75.47	35
Naphthalene dust	200	12.80	70.79	37
Nicotine dust	75	65.55	45.87	57
Naphthalene on the row	300	22.50	62.08	12
Naphthalene broadcast	300	22.50	55.36	21

the crude chipped naphthalene by hand. This however, does not take into consideration the initial cost of the dusting machinery. Any machinery used in onion fields at the time when the thrips are most abundant is certain to result in some injury to the plants. This fact together

with the cost of the materials has probably been the chief factor in the failure of onion growers to use nicotine sprays and dust of proven merit to protect their crops from the damages caused by the onion thrips.

The results of these experiments indicate that both naphthalene-hydrated lime dust and undiluted crude chipped naphthalene applied by hand will control onion thrips. If however, dusting machinery is available, most economical and satisfactory protection may be obtained by using a naphthalene-hydrated lime dust.

POTATO SPRAYING AND DUSTING EXPERIMENTS ON LONG ISLAND

By H. MENUSAN, JR., and WM. DICKISON, *Ithaca, N. Y.*

Spraying and dusting experiments with Irish Cobbler and Green Mountain potatoes have been conducted at Hicksville and Central Park, Long Island, for the last four successive seasons, 1930 to 1933, to determine the most efficient methods of application.

The seasons, from 1930 to 1933, were dry; an average of 5.91 inches of rain falling during the combined months of June and July in comparison with an average of 8.78 inches for a 21-year period prior to 1930. However, even with this decrease in rainfall average yields of potatoes were obtained in all years except 1933 when the crop fell slightly below the average.

Plant diseases, such as early blight and late blight, were of no importance in the experimental plots; late blight was not found in any plots and few lesions of early blight were present. Flea-beetles, leafhoppers, the Colorado potato beetle, and aphids, were the only insects which occurred in large numbers.

In the experiments reported, spraying and dusting operations usually commenced when the Colorado potato beetle larvae appeared, and from then on applications were made at weekly or ten-day intervals until the plants were dead. The first dust or spray application was usually made the first week of June and the last the latter part of July in the case of the Irish Cobblers, while the last application on the Green Mountain potatoes was made the first week in August. The number of spray or dust applications varied from 4 to 6 on the Cobblers and from 5 to 8 applications on Green Mountain potatoes.

The sprays were applied with a horse-drawn power machine carrying a six-row boom with three nozzles to each row. The bordeaux sprays,

unless otherwise stated, were of a 4–4–50 concentration prepared by adding a thin paste of hydrated lime to a dilute copper sulfate solution. All sprays were applied at 400 pounds pressure, and at the rate of 125 gallons to the acre in each application. The dust—a 20–80 bordeaux dust—was applied at the rate of 35 pounds to the acre, by means of either a traction or power machine, on windless mornings when the potato foliage was wet with dew. Each duster was capable of dusting six rows and had two distributors to each row.

In every dust-spray experiment the application of materials was invariably completed the same day, and care was taken to apply the same amount of copper in both treatments. All plots, including the checks, were treated with calcium arsenate to control the Colorado potato beetle.

The strip-row method was used in planning the experiments, each plot consisting of six rows and being replicated two or more times as conditions permitted. An unsprayed plot or check separated each treatment so that adequate comparison could be made between adjoining plots. Yield data was obtained by weighing the entire plot. This data was then treated statistically by the variance method (3, 5)* to determine the confidence which could be placed on the results.

The results obtained from spraying and dusting, both Irish Cobbler and Green Mountain potatoes in Nassau County, Long Island, over the four-year period from 1930 to 1933, are shown in Table 1. It may be noticed that over the four-year period an average decrease of 16.9 bushels per acre was obtained in the case of the dust and an average decrease of 9.1 bushels per acre in the case of the spray. Taken as a whole, these decreases are not statistically significant[1] although statistically significant reductions were obtained in 1932. Huckett (4), reviewing the results of five years experiments (1926 to 1930) with Irish Cobbler and Green Mountain potatoes on Long Island, failed to demonstrate any significant increases in yield from spraying and dusting.

Most of the decreases in yields obtained are probably due to mechanical injury from sprayer or duster. The horses and wheels of the sprayer or duster, while treating the six rows of each plot, passed on the outside of the ridges of the middle two rows, causing an average decrease of 8.6 bushels per acre to these rows. Blodgett, et al. (1) report average injury from sprayers of 15.0 bushels per acre on the middle rows, this greater

*References to literature cited.

[1]Differences greater than 2.15 times the standard error of mean differences are considered significant. This gives odds of 30:1 that the differences are not due to chance.

injury being, no doubt, due to the larger number of spray applications in each experiment in their comparisons. The wheel injury, on the two rows adjoining the middle rows, was only half that of the middle rows while the above authors reported equal amounts of injury to the middle and adjoining rows.

DISCUSSION OF RESULTS.—The results of these experiments show that consistent decreases in yield of tubers result from treating potatoes with either spray or dust according to the recommended spray program.

Weather conditions during the growing season of 1932, were similar to those of the other three years, rendering it improbable that the minor weather variations were a factor in the decreases in yield obtained in that year. The abundance of insect pests was also practically the same during the four-year period reported on. The majority of the spray and dust applications in 1932 were made earlier in the season than in the other years.

In different potato growing sections (1) it has been found necessary to decrease the concentration of hydrated lime in bordeaux for the largest tuber yield. Similarly the most effective bordeaux has been reported to be one containing four or five pounds of copper sulfate in fifty gallons of water. In Nassau County, Long Island, the following modifications of the spray program were tried in attempts to increase the tuber yield or at least reduce to a minimum the decreases obtained: first, the hydrated lime concentration in bordeaux was reduced while the copper concentration was held constant; second, the concentration of the materials in the bordeaux was varied; and third, the total number of applications were reduced and those applied were timed to give the greatest protection. These modifications were tested in 1932 and 1933. In general, similar results were obtained in both years but again statistically significant results were obtained only in 1932. For simplicity, the discussion which follows will deal only with the results of 1932.

Changes in the hydrated lime concentration in bordeaux did not have any particular effect on the yield when six applications of spray were made during the season (Table 2). In this experiment the sprays gave excellent control of the insect pests though a significant reduction in tuber yields under the unsprayed plants was obtained. Similarly, with five applications of different bordeaux concentrations, the largest yield was obtained with the weakest concentration. Bordeaux stronger than 2–2–50 gave reductions, in yield below the unsprayed plants (Table 3).

The preceding experiments indicate that the decrease in yield may be due to applying too much copper to the potato foliage. The total amount

of copper applied was reduced by applying only three applications of 4–4–50 bordeaux during the season. These three applications were made at different periods in an attempt to determine the most effective time of application for the greatest protection with the least amount of injury. The results obtained with these three applications are summarized in Table 4. Three applications of bordeaux in June when the potato vines had not reached their maximum growth resulted in a decrease in tuber yield of 23.3 bushels per acre below that of the non-sprayed plants. On the other hand, three applications of bordeaux in July, after the potato plants had reached their maximum growth and leafhoppers were more abundant, resulted in a gain of 10.9 bushels per acre above the unsprayed vines. Three applications of spray during June and July did not materially change the yield, the 4.4 bushels per acre reduction was probably due to mechanical injury by the sprayer. This experiment shows that spraying relatively early in the growing season reduces the total tuber yield while later applications give an increase in yield. Early and late applications combined gave approximately the same yields as the unsprayed plots. The spray practice followed in Nassau County, Long Island, is to "protect" the potato foliage during the entire growing season. The experimental results obtained would indicate that increases derived from late applications of bordeaux would be neutralized by the reduction in yield of tubers from the early applications. Results summarized in Table 1 show that the above probably has happened.

The results may in some respects be comparable with those of Bonde (2) in Maine, who states that "In Aroostook it has been shown that bordeaux has a depressing effect on the yield, especially in years of no late blight. This depressing effect can be diminished by reducing the concentration of the materials used in the preparation of the bordeaux mixture" and that "the delayed spray program gave yield rates equal or superior to those of similar plots where spraying began early and was continued throughout the season."

SUMMARY.—Four successive years of potato spraying and dusting experiments in Nassau County, Long Island, show that little or no increases in yield of tubers have been secured with the procedures tested. On the contrary consistent decreases have resulted where the potato vines were sprayed according to the generally accepted spray program. The average decreases in yield under the unsprayed plants in the spray-dust experiments, averaged 16.9 bushels per acre in the dusted and 9.1 bushels per acre in the sprayed plots. Applications of spray relatively late in the season resulted in an increase of 10.9 bushels per acre, whereas,

those sprayed earlier in the season gave a decrease of 23.3 bushels per acre as compared with the unsprayed plots.

TABLE 1. THE EFFECT OF SPRAYING AND DUSTING ON THE YIELD OF COBBLER AND GREEN MOUNTAIN POTATOES ON LONG ISLAND

Year	Variety	Yield of check in bushels per acre	Number of replicates	Average increase or decrease in bushels per acre		Standard error
				Dust	Spray	
1930*	Green Mts.	206.0	2	— 2.9	— 8.4	10.6
1931	Green Mts.	203.8	4	— 3.5	— 4.4	4.0
1931	Cobblers	275.3	2	— .3	5.1	4.2
1932	Cobblers	267.0	2	— 8.0	2.2	7.0
1932	Cobblers	239.6	4	—25.4	—28.6	13.1
1932	Green Mts.	215.8	5	—27.7	—21.2	3.9
1933	Green Mts.	238.8	3		7.2	6.1

Average decrease in yield of dust under check, based on 28 comparisons, is 16.9 ± 8.5 bushels per acre.

Average decrease in yield of spray under check, based on 34 comparisons, is 9.1 ± 7.9 bushels per acre.

*Data collected by G. W. Simpson.

TABLE 2. THE EFFECT OF VARYING THE AMOUNT OF HYDRATED LIME IN BORDEAUX MIXTURE ON THE YIELD OF GREEN MOUNTAIN POTATOES WHEN THE AMOUNT OF COPPER IS HELD CONSTANT. THE AVERAGE YIELD IS BASED ON SIX REPLICATIONS IN 1932

Treatment	Average yield in bushels per acre	Difference in favor of spray
4–1–50	181.0	—8.6*
4–2–50	180.9	—8.7
4–4–50	183.2	—6.4
Check	189.6	

*Differences of 7.3 bushels are probably significant.

TABLE 3. THE EFFECT OF VARYING THE CONCENTRATION OF BORDEAUX MIXTURE ON THE YIELD OF GREEN MOUNTAIN POTATOES. THE AVERAGE YIELD IS BASED ON FOUR REPLICATIONS IN 1932

Treatment	Average yield in bushels per acre	Difference in favor of spray
2–2–50	193.2	14.3*
4–4–50	176.0	—2.9
8–8–50	173.3	—5.6
Check	178.9	

*Differences of 8.3 bushels are probably significant.

TABLE 4. YIELD OF GREEN MOUNTAIN POTATOES AS AFFECTED BY THREE APPLICATIONS OF BORDEAUX MIXTURE (4–4–50) AT DIFFERENT PERIODS. THE AVERAGE YIELD IS BASED ON FOUR REPLICATIONS IN 1932

Treatment	Average yield in bushels per acre	Difference in favor of spray
June	172.1	—23.3*
June and July	191.0	— 4.4
July	206.3	10.9
Check	195.4	

*Differences of 13.2 bushels are probably significant.

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MR. HARTZELL: What is the explanation for the decrease?

MR. DICKISON: In some cases wheel injury has resulted in decreases. In the case of spray dust experiments there was a decrease of 8.6 bushels on the two middle rows. As you know the sprayer goes down on the outside of the two middle rows and the injury to the two middle rows or rows 3 and 4 was 8.6 bushels.

MR. DIETZ: Very interesting results have been worked out and published by the Ohio Experiment Station by Wilson, which indicate under drought conditions Bordeaux, through an increasing of the transpiration rate of plants, killed them. I was just wondering whether that effect may be applicable here.

MR. DAVIS: I would like to ask the author in that last table shown where there were three different types or kinds of application, were those on the same age plants or different plantings?

MR. DICKISON: They were on the same aged plants. The idea behind the experiment was to see if it was feasible to reduce the number of applications, since it appeared perhaps too much copper was causing our reductions in spray-dust experiments.

MR. DAVIS: The reason I asked that question is for the last five years we have carried on a series of spraying and dusting experiments in the northern part of Indiana, on both early and late potatoes. In the case of the late potatoes we invariably had decided increase in yield that more than paid for the spray in particular, and usually for the dust. In the case of the early potato quite frequently the increase in yield would not pay for the spray or dust. I attribute that largely to the fact that the insects are not present early in the season.

MR. HARTZELL: I would like to ask whether calcium or magnesium lime was used in preparing Bordeaux.

MR. DICKISON: We had experiments which included the magnesium and calcium lime. Very little difference was found. These experiments were with calcium.

SOME EFFECTS ON POTATO FLEA-BEETLE (*EPITRIX CUCUMERIS* HARRIS) INJURIES AND YIELDS BY SPRAYING

By D. O. WOLFENBARGER, *Ithaca, New York*

The studies herein reported are some results of experiments carried on in Western New York on muck land potatoes. The practical value of adding stomach poisons to bordeaux mixture in the potato spray program for flea-beetle was the chief point under consideration, since there appears to be a lack of agreement between workers as to the value of this practice except for use against the Colorado potato beetle.

The effect of the various treatments in preventing flea-beetle injury to the leaves was determined by counting the number of holes per leaflet. The effect of the treatments in preventing larval injury to the tubers was determined by counting the number of injuries per tuber. Yield figures were obtained by weighing the tubers in the fields at digging time.

Commercial fields of Irish Cobbler potatoes of two to three acres were used. The plots were four to six rows wide and ran the length of the rows (800 to 1000 feet). The fields were too narrow to permit more than two or three replications, but the plots were further divided by selecting areas across the rows, directly opposite each other for the purpose of taking data.

The sprays were applied with horse-drawn power sprayers using three nozzles per row. The plants were sprayed at pressures varying from 250 to 350 pounds and at rates of 65 to 125 gallons per acre depending on the size of the plants. Ten sprays were applied in 1931, eight in 1932, and six in 1933,[1] at intervals of five to twelve days during the growing season. The check rows were sprayed once in 1931 and twice in 1932 and 1933, with two pounds of calcium arsenate to 50 gallons of water to destroy the Colorado Potato beetles.

[1]Acknowledgments are due to Mr. H. Menusan, Jr., who carried on the experiment in 1933.

The following materials were tested: bordeaux mixture 5–7–50 alone, bordeaux combined with two pounds of calcium arsenate, and bordeaux with two pounds of lead arsenate per 50 gallons. In 1932 and 1933 barium fluosilicate was tested at the rate of two pounds to 50 gallons of bordeaux.

Counts of flea-beetle holes were made at row by row stations in each replication and plot. Five to seven counts were made each season at intervals of six to twelve days. Single side leaflets were taken from the upper third of the plant at each station.

Counts of larval injury were taken by selecting a single tuber from each row in each plot after the plants were dead and prior to harvesting. The size of the tuber taken was one which would pass through a three-inch hole, but would not pass through one of three and one-sixteenth inch diameter. The tubers were washed and dried or very carefully brushed to enable accurate examination. Each distinctly separate injury produced by the larvae was recorded. These data were compared statistically according to Fisher's Variance Method.[2] Areas of 1/100 acre in size, in each row were sampled at harvest time by weighing the potatoes as they were picked up and put into crates.

Discussion of Results.—The increases in yields which may be attributed to the control of the potato flea-beetle have not been clearly demonstrated. From the data in Table 1, regarding flea-beetle injuries to the leaflets little increases in yield attributable to the reduction of these

Table 1. Average Number of Flea-beetle Injuries to Leaflets and Tubers Together with Differences of Treated over Check and Average Yields

	Flea-beetle holes in leaflets		Flea-beetle larval injury to tubers		Yields
	Average number of holes per leaflet	Number of holes less than check	Average number of injuries per tuber	Number of injuries less than check	Average bushels per acre
Check	39.2		14.9		308.7
Calcium arsenate and bordeaux	21.8	17.4	10.8	4.1	412.7
Barium fluosilicate and bordeaux	25.5	13.7	12.8	2.1	320.6
Lead arsenate and bordeaux	25.4	13.8	11.2	3.7	407.5
Bordeaux alone	23.8	15.4	11.6	3.3	384.2
Number of comparisons	332		55		11
Standard error of difference		±3.4		±1.8	

[2]Wishart, John. Methods of field experimentation and statistical analysis of the results. In Rothamsted Conferences XIII, The Technique of Field Experiments. P. 13–21, 1931.

injuries might be expected. The large differences in yields obtained were obviously due, in part at least, to control of leaf hoppers and early blight. It is interesting to note, however, that calcium arsenate and bordeaux, as a spray, not only resulted in the largest yields but also afforded greatest protection from flea-beetle feeding. From the standpoint of yields lead arsenate and bordeaux was more efficient than bordeaux alone. The use of barium fluosilicate combined with bordeaux gave the least protection from flea-beetles and the smallest increase in bushels per acre over the check.

All treatments were very effective in reducing the number of feeding holes on the leaflets; however, the most effective treatments did not provide perfect protection. The reduction below the check in the number of holes per leaflet where calcium arsenate combined with bordeaux was used is highly significant, as judged by a difference of twice the standard error. Bordeaux mixture alone ranked second in the reduction in numbers of holes per leaflet under the check. Lead arsenate combined with the bordeaux and barium fluosilicate combined with bordeaux were least effective in preventing leaf feeding. None of the treatments, however, were significant over one another.

An examination of the average numbers of larval injuries per tuber in Table 1 shows no large differences. Apparently the amount of reduction of adult feeding injuries on foliage was not reflected in a like reduction of larval injuries to tubers. Some significance may be attached to the consistency with which calcium arsenate combined with bordeaux shows the greatest reduction of feeding on the leaflets and tubers and the harvest of the largest yields, as compared with the other treatments. None of the bordeaux combinations tested afforded a practical control of the flea-beetle larvae as judged by tuber injuries.

SUMMARY.—Three years' experiments comparing bordeaux mixtures alone and in combination with lead or calcium arsenate or with barium fluosilicate as potato sprays show these materials do not offer adequate control of the potato flea-beetle. Some reductions were made in the adult feeding on the leaflets of the plants but these results were not reflected by any material reduction of larval feeding on the tubers. Bordeaux mixture of 5–7–50 combined with two pounds of calcium arsenate was the most effective of the materials tested. This material gave a reduction of 17 holes per leaflet and four feeding scars less than the check with a corresponding gain of over 100 bushels per acre more than the check.

CHINCH BUG RESISTANCE IN CORN—AN INHERITED CHARACTER

By J. R. HOLBERT, *Senior Agronomist, Bureau of Plant Industry, U. S. D. A., Bloomington, Ill.*, W. P. FLINT, *Chief Entomologist, State Natural History Survey and Agricultural Experiment Station*, and J. H. BIGGER, *Field Entomologist, State Natural History Survey, Jacksonville, Ill.*

Fig. 2.—Inbreds Hy and A, respectively, from left to right. Inbred Hy ranks high in chinch bug resistance. Inbred A is low in chinch bug resistance.

Cooperative corn investigations have been conducted in Central Illinois for a period of years. One important outgrowth of these studies has been the development of several inbred lines that possess more than average resistance to some of the important corn diseases as well as considerable resistance to cold, heat, and drouth. Some of these inbred

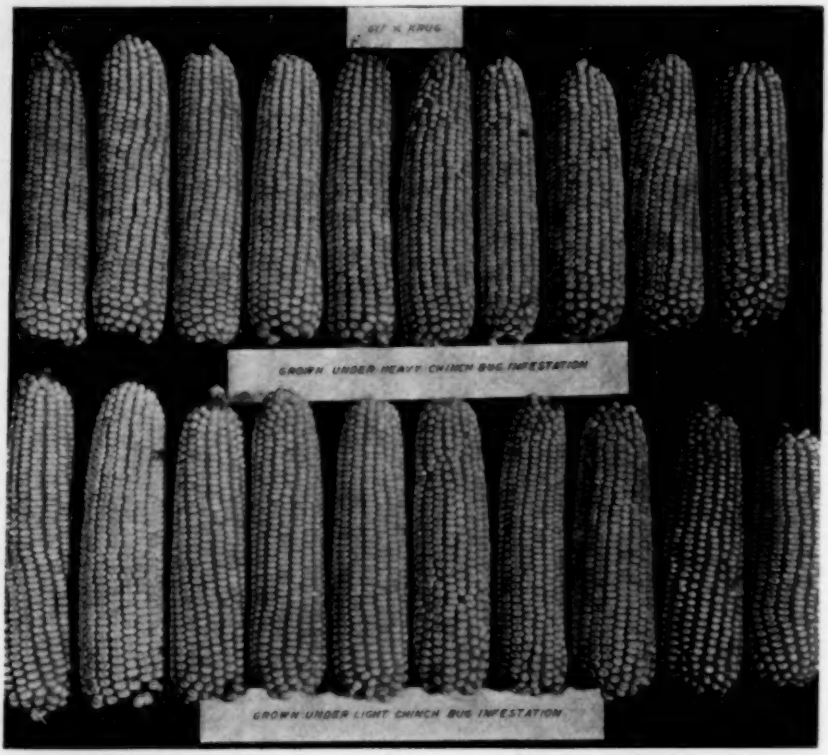

Fig. 3.—617 is a highly chinch bug resistant inbred. This, when crossed with Krug, carries the resistance to the cross.

lines have been combined into hybrids which for the past few years have consistently stood up better at harvest time and given significantly increased yields of sound corn, as compared to those strains and varieties now commercially grown.

For the first time in the development of the inbred lines and hybrids referred to above, a period of more than 15 years, these strains of dent corn were in 1933 subjected to severe chinch bug infestation. Other corn belt inbreds contributed by workers in neighboring states, and top

crosses and hybrids involving these inbreds, were included in the plots that were heavily infested with chinch bugs. The field plots, planted on several different dates, were located in a number of fields. Some of the hybrids were grown under heavy chinch bug infestation in four widely separated counties in Central Illinois.

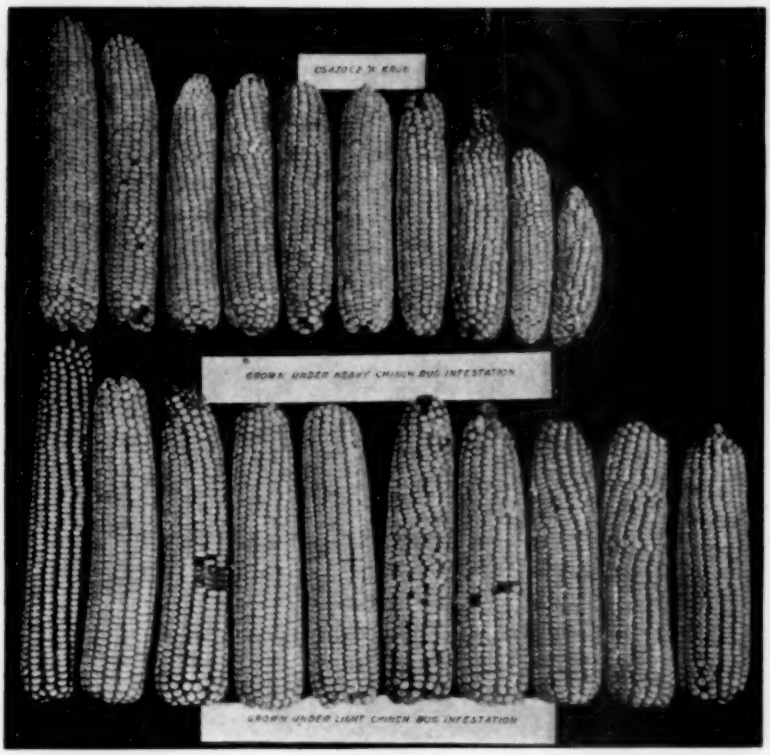

Fig. 4.—Krug is one of the most generally grown commercial varieties of corn used by Illinois farmers. It is not noticeably chinch bug resistant.

Inbred OS 420 C2 is a chinch bug susceptible corn which, when crossed with Krug, imparts susceptibility to the cross.

The data taken from these plots indicate that some inbred lines carry dominant factors for chinch bug resistance while other inbred lines carry dominant factors for chinch bug susceptibility. The results suggest also that strains of corn may be developed which will combine chinch bug resistance in a significant degree with other important characteristics concerned with satisfactory yield of high quality grain.

The results of the work here reported while covering a period of one year only, are so definite and clear cut that they appear to be worth recording.

The accompanying illustrations show the results much better than they can be described.

SYMPOSIUM ON THE SPRAY RESIDUE PROBLEM

Austin Hall, Harvard University, December 29, 1933

Conducted by P. J. Parrot, Geneva, N. Y.

CHAIRMAN PARROTT: Those of us who are concerned primarily with the control of the codling moth have during recent years experienced great difficulties because of the abundance and the destructiveness of the codling moth in certain areas during recent years; also difficulties have been experienced in some instances to secure economic and efficient control; and lastly, the restrictions of the Food and Drug Administration relative to spray residues, leading to complications which impose great burdens on the fruit and vegetable interests, as well as the spray service.

Those of you who were present at the meeting last year at Atlantic City and have kept in mind the difficult situation which the spray service had to contend with, agree with me that one need was pointed out last year and that need is clearly the desirability of close cooperation on the part of all agencies that have to do with spray residue and control of injurious insects on vegetables and fruits.

I take it that this program is a beginning step in that direction. Fortunately, the Food and Drug Administration have made the announcement relative to spray tolerances allowed for this year. A representative of that same organization is going to give us a picture relative to spray residue on fruits and vegetables going to the market.

In addition, we have a number who are going to tell in a broad way about the situation this past year relative to the importance of tests in vegetables and give us some intimations as to the effectiveness of the most promising materials in combating the pests. I hope before the discussion is over we will be able to come to some conclusions as to the most practical measures for fighting these various pests next season.

THE CURRENT SEASON'S EXPERIENCE IN ENFORCING SPRAY RESIDUE TOLERANCES

By W. B. WHITE, *United States Food and Drug Administration*

Naturally, this presentation will deal mainly with the public health aspects of the whole vexatious poisonous spray residue problem, with special emphasis on lead, since lead compounds, among all the insecticides in common use, are doubtless most dangerous. I have qualified this statement somewhat because of the recent emergence of mercury and selenium compounds in this field. Mercury, in various organic combinations, has been recommended for certain leafy vegetables and as an emulsifying agent for citrus sprays. The exceedingly deadly nature of mercuric compounds causes us the gravest apprehension even though it is asserted that no poison can possibly contaminate the edible portion of the food. This has too often been assumed in the past to the sorrow of regulatory officials. I cite cauliflower and peas as examples. The form in which selenium is used as an insecticide is probably of relatively low toxicity. The menace here is the tendency for selenium compounds to enter the plant metabolism and to replace sulphur in the harvested crop. In this form selenium produces effects upon higher animals which can only be characterized by the term "ghastly."

The discussion will deal mainly with fruit with some incidental reference on vegetables. Before touching upon some of the high spots of the year's regulatory campaign, and citing what statistical material our over-worked field force has been able to collect, I want to give you a thumbnail sketch of the historical background of spray residues in the United States.

It was natural that in earlier years entomologists, faced with the staggering problem of so controlling insect infestation as to produce the perfect fruit increasingly demanded by the consumer, had little time and energy to conduct extensive researches upon the probable effect on human health occasioned by the constant increase in spray residues and the growing difficulty of their removal. When we are in the midst of events in which we are taking an active part, it is almost impossible to maintain a historical perspective. But as time went on and the medical profession began to be increasingly conscious of the danger of chronic poisoning from insecticide residues, the press in various sections of the country began to carry accounts of illness which had been diagnosed as arsenical poisoning from sprayed fruits or vegetables. Some of this publicity, as you know, was most sensational, and, in many cases, unfair

and inaccurate. There was, however, a sufficient kernel of truth in many of these reports to justify some of the public apprehension which they aroused. The years which I may characterize as the period of skepticism brought to entomologists an increasing realization of the public health aspects of the problem. The creation of the Departmental Spray Residue Committee, December, 1932, marked the final step in the consolidation of all Federal researches on the different aspects of the spray residue problem, to the common end of public health protection. The heartening progress made by this committee to date, is a monument to cooperative effort. I need not go into detail as to the various lines of attack. Substitutes for arsenic, lead and fluorine are being investigated, both from the standpoint of pest control and their effect on higher animals. Fruit washing technique has been intensively investigated and great progress made. Analytical methods for lead, so necessary from the public health angle, have been developed to a point where it takes but thirty minutes for an accurate lead determination instead of three days, as was the case early in 1933. Non-spraying methods of pest control, depending upon proper cultural technique, poison baits, traps, and the like, are producing encouraging results. In one of the important grape producing centers, cultural methods bid fair to afford complete solution of the spray residue problem.

In commenting on the current season's experience, there is little necessity for touching on spray schedules or washing experiments, since these will doubtless be handled by specialists in these fields. The experience of the fruit industry seems to confirm the experimental washing data as to the difficulty of removing arsenic and lead from apples carrying late nicotine and oil sprays.

It is hardly necessary before this audience to dwell upon the magnitude or the unpopularity of the task of controlling interstate shipments of sprayed fruits and vegetables. For some time past this has absorbed about one-third of our time and money. Outbreaks of excessive spray residue on vegetables are as sporadic as are certain diseases, and they have caused almost as much hysteria. In one city the price of loose-leafed cabbage dropped fifty per cent overnight due to seizures occasioned by the wanton and reckless use of lead arsenate by ignorant growers. There is practically no month in the entire year when it is impossible for an explosion of this sort to occur, calling for our almost undivided attention for a number of weeks. It is indeed gratifying that, as far as vegetable foods are concerned, lead is well on its way out of the picture. Thus far, since July 1, 1933, we have seized the following shipments—apples 38, crabapples 4, currants 27, making a total of 69 fruit shipments. The

vegetable situation has been comparatively quiet, with only 1 shipment of broccoli and 4 of cauliflower seized. The ever-increasing proportion of interstate shipments by truck is one of our most serious problems, both in fruit and vegetable control. Extensive truck shipments of vegetables move out of Florida, and the interstate shipment of fruit by truck is prevalent in Michigan, Illinois, Arkansas, Idaho, Colorado, and, to a lesser extent, in other states. Until there is Federal regulation of this type of interstate commerce, this will be a continuous thorn in our side. We have sometimes had to institute a 24-hour patrol of important interstate highways. In general, we have been reasonably successful in sampling truck shipments and taking legal action at destination. State cooperation can be very effective in this field but, unfortunately, few states have a sufficient appropriation to effect 100 per cent coverage. It is interesting to note that the State of Montana this season has instituted effective patrol of its borders to prevent the shipment *into* the state of fruit high in arsenic and lead.

I know that you are interested in the arsenic and lead content of fruit the country over. I have passed around some mimeographed tables which give all of the analytical figures from responsible sources which we were able to obtain up to December 15. They have been separated into three groups, orchard samples, interstate shipments (abbreviated to I.S. in the tabulation), and packing house and other market samples. You are cautioned against drawing sweeping conclusions from such necessarily fragmentary data. The percentage of "high" samples in any locality is only the roughest sort of an index of conditions as a whole. It is obvious that all of the analyses are on samples which, for one reason or another, were suspected of being above the tolerances. This is especially true of interstate shipments and, to an almost equal degree, of packing house samples. In general, any conclusions drawn from the analytical data must be qualitative rather quantitative. Orchard samples, to a certain extent, reflect state service, especially in the East. In other sections where spray schedules are heavier, and especially in the Pacific Northwest, very few orchard samples are taken because it is virtually certain that the fruit will have to be washed. Here, the emphasis must be upon packing house samples, interstate shipments and export fruit. It will not be profitable to make comparisons between the number of Federal seizures and the number of high lots in any of the tables. The high orchard and packing house samples were, of course, practically all recleaned and many of the high interstate shipments were embargoed at destination by local officials and recleaned or destroyed without the for-

mality of Federal seizure. The total samples examined are, perhaps, an exceedingly rough index of production, but there is some duplication on the packing house samples from the Pacific Northwest, as is indicated by the footnotes. A comparison of the last two columns under the caption "Lead" seems to indicate that, except in Idaho and the Pacific Northwest, about twice as much fruit would have failed to meet the .014 tolerance as failed to meet the current tolerance of .02. In the latter regions indications are that a tolerance of .014 would have condemned some four to six times as much fruit as the present tolerance. The difficulty here is the fact that considerably more than half the spray residue load of washed apples may be tightly held in the stem and calyx cavities. For example, it has been found necessary in analytical work to lightly ream out the blossom end so that the solvent can penetrate into this almost capillary space. It would be fatuous to assert that all fruits and vegetables are absolutely without adverse effect on human health. Our eating, in common with every act we perform, is subject to the hazards of civilized life. We do feel, however, that the overwhelming majority of fruits and vegetables in interstate commerce is absolutely safe for human consumption. There are some definite indications that, where state control is for any reason ineffective, intra-state shipments may carry noticeably higher amounts of residues. We are now advising inquiring consumer correspondents that to be doubly safe, they may wish to cut away the stem and calyx cavities of apples, and the calyx cavity of pears, before use, thereby discarding the major portion of the remaining spray residue.

In the Pacific Northwest the lead sulphide colorimetric method was mainly used in determining lead. This requires about 1½ hours. We were not able to evolve a shorter, less complicated and more accurate colorimetric method until the industry was well into the harvesting season. With the normal production of perhaps 50,000 to 60,000 carloads, the change in methods could not be effected in mid-season. However, now that the rush is over, it is thought that the newer colorimetric method, issued September 27, will be rather universally adopted. This takes but half an hour.

Never before has the attack against fruit bearing excessive spray residues been prosecuted upon such a wide and united front. In the State of Washington, which, of course, produces the lion's share of apples, unstinted credit goes to Mr. Walter J. Robinson, the recently appointed Director of Agriculture, and his subordinates for the splendid control measures instituted in that state. This policy reflects the far-sighted view that the production of absolutely safe fruit is vital to the welfare of

the industry itself. The monumental size of the task is reflected in the number of samples examined in the tabulation of packing house analyses which has been distributed. The State Department of Agriculture has taken a firm stand that if apples are not safe for export or interstate shipment, they are not safe for the citizens of the state. The records of the industrial laboratories have been opened to the scrutiny of state and Federal regulatory officials, and each grower's lot, as it was washed, was given a code number. Against lots showing lead or arsenic above the tolerances condemnation certificates were issued and the fruit was not allowed to move out of storage and into consumption unless and until it was recleaned to a safe point. A joint state and Federal supervision of industrial analytical laboratories was instituted and, wherever careless or incompetent work was uncovered, effective corrective measures were carried out. Here, as elsewhere, the ghost of rugged individualism still walked now and then, but the recalcitrant minority was much smaller and less threatening than in earlier years, when on more than one occasion actual mob violence was imminent. In all fairness it should be stated that the residue control problem is immeasurably more serious in this region than in any other section of the country.

In the State of Oregon the local regulatory officials were well up to their previous high standard of cooperation. In this section the analytical laboratories were supported by the State Department of Agriculture. The difficulty of changing analytical methods in mid-season has already been touched upon. In spite of this the Oregon laboratories found the electrolytic method for lead so superior, that their later analyses were made by this method alone.

Passing now to other producing sections, I shall touch briefly upon the cooperation afforded by state and municipal officials, and by the industry, with the distinct understanding that the omission of certain states may, and almost universally does, mean that either it was so much taken for granted that it was not mentioned by our field forces, or that the deplorable financial condition of certain states made it impossible. Aside from the important educational features of local cooperation, this type of assistance may take two general directions: The analysis at state expense of orchard and packing house samples followed in some cases by state embargo of high lots, or, where local laws permit, the embargo of interstate shipments at destination for a sufficient time to enable our field force to secure and analyze a sample, and to obtain from the Federal courts a libel condemning the shipment if it proves to be in violation of the food and drugs act. Besides the states already mentioned, the following stand high in the field of analytical service to the industry:

California, Michigan, New York, Pennsylvania, New Jersey, Delaware, West Virginia, Virginia and Maryland. There are doubtless others but these have received special mention in the reports which have come to us. In the field of regulatory cooperation the embargo of the State of Montana against dangerous fruit from outside the state has already been mentioned. Municipal cooperation has been excellent in Tulsa, Oklahoma, where it was badly needed in solving the vexatious problem of truck shipments. It has also been excellent in Chicago, where a similar situation prevailed. In the east, Boston, Baltimore and New York may be mentioned and in the west, Los Angeles. There are doubtless many others. Besides Washington and Oregon, the following states have been mentioned in the reports: California has an excellent system of state certification of their own fruit with a practically 100 per cent sign-up by the industry. Idaho, Texas, Kentucky, Indiana, Wisconsin, Illinois and New York have received special mention. From past experience in state cooperation I know that, though not mentioned, it has been forthcoming whenever requested in practically every state in the Union.

There has been a notable increase in washing equipment in those localities which had previously been able to meet fairly well the less drastic tolerances. In New York State, for example, nine large washing machines have been added in a region where there were but two last year. More would have been installed had it not been for the serious water shortage prevailing. Twenty-nine new washing machines were reported in Michigan. In the Northwest there was unutterable confusion in spray schedules because of the drastic campaign against lead which became necessary the previous winter. In the face of so much uncertainty, "shotgun" spray mixtures were resorted to which greatly increased the difficulty of cleaning. In many instances even "white arsenic" was purchased from drug stores to "spike" the regular spray mixture, with sometimes disastrous results. Manganese arsenate introduced a serious interference into the earlier analytical methods. In a few cases incompetent chemists turned in results which were in excess of the actual lead present and, in the recleaning process, desperate operators boosted the temperature and the concentration of chemicals to a point which seriously damaged the fruit. In spite of all these handicaps, our Seattle office reports that failure to clean to a satisfactory point was, in most cases, due to carelessness or neglect in washing and not so much to the fact that a particular lot of fruit was refractory. An increasing number of plants have installed thermostatic heat control and are subjecting their washing solutions to frequent tests to assure optimum strength; too much will damage the fruit, too little will not remove the lead. Obviously,

the cleaning of high residue fruit is a matter calling for rigid and intelligent control. It is, indeed, remarkable that with the rule of thumb methods still prevailing in the majority of cases, such a small percentage of washed fruit failed to meet the .02 lead tolerance. The Secretary of Agriculture has recently announced for the coming year a lead tolerance of .019 grain per pound for fruit. With the stabilization of spray schedules and the application of the knowledge gained by extensive washing experiments, this tolerance should be easily met in the 1934 season by all operators who provide adequate analytical control. With such success where removal is so difficult, obstructive tactics by small orchardists in the lighter producing sections seem ill-advised. The time has come when the production of wholesome fruit can no longer be safely left to the vagaries of climatic conditions. I think that it may be definitely asserted that the aggregate lead intake by consumers through the medium of sprayed fruit has undergone a sharp reduction during the last 12 months over that of the previous year.

What the future holds in store in the field of non-lead insecticides is not now predictable. Certainly the pressure to eliminate lead, as well as arsenic and fluorine, will become increasingly great from all quarters. As lead has grown in disrepute, fluorine compounds have come to the fore. I regret to say that enthusiastic high pressure salesmen have grossly belittled the human health hazard of this type of insecticide. We have consistently maintained the position that the latest knowledge indicates that fluorine compounds may be every bit as dangerous from the standpoint of chronic poisoning as are arsenic compounds. The argument has been advanced that the less soluble fluorine compounds are less toxic than those which are more soluble. While this is true at higher feeding levels (where much of it probably does not enter the circulation), our latest information, based on intensive studies at the Arizona Experiment Station, is to the effect that cryolite is only about one-half as toxic as soluble fluorine compounds when fed at a level of 7 parts per million in the diet of rats. At this level it produces pathological changes in the teeth and the minimum has not yet been reached. Barium fluosilicate seems to be every bit as toxic as soluble fluorides. There are definite indications that, contrary to early predictions, fluorine compounds, when used with the same type of oil sprays, are much more difficult to remove from apples than arsenate of lead. The dental profession is becoming very conscious of the danger of chronic fluorine poisoning, and the growing interest of the medical profession in the lead and arsenic problem has been strikingly evinced by the flood of letters which have come across my desk from physicians, medical col-

leges and foundations asking for information on the latest methods for determining lead.[1] These methods have had no publicity in the medical press and only scant mention in one or two of the more or less popular scientific publications, yet since these notices appeared some two months ago, there is still an average of one letter per day from the medical fraternity.

Whether nicotine and oil or some of the other organic insecticides will completely displace arsenate of lead in the control of late broods of the codling moth is not certain. I do venture to predict, however, that the consumer and the agencies which protect his health are not going to accept with complacence the exploitation of new insecticides until these are developed with one eye, so to speak, on the consumer, the other on the worms. I mean that, hand in hand with the experiments on pest control, there will be carried out, by absolutely disinterested scientists, experiments on higher animals designed to establish, as conclusively as can be done, the probable or possible effect upon human health of the quantities of these materials which unavoidably remain on the product at the time of consumption. This, of course, means the concurrent development of analytical methods to test the efficiency of washing technique and to follow the course of the poisons in animal metabolism. This sounds like a large order but the public will stand for nothing less. Fortunately, we seem to have stopped far short of the brink of widespread chronic lead poisoning. Let us not again go along for years putting on other poisons in total ignorance of the amounts going to the consumer and of the effects upon his health.

MR. HEADLEE: Why, with all the expenditure that this spray residue method entails, has not the government put on a physiological study which was requested early in this game, long before these expenditures had more than begun. Nothing has been done so far as I know. Apparently the opinion of the toxicologists has been taken as full and sufficient. Why was such a study not put on in view of the size and importance of the problem? I am referring to arsenic and lead.

MR. WHITE: Speaking for my own Bureau only, we regard the danger to human health as already proven. I know that toxicologists are more dubious and more conservative in their attitude toward lead as I have talked with them than they were in 1927.

There have been no human feeding experiments that I know of recently by the government or by anybody else so far as I am aware. You

[1]These appear in the Journal of the Association of Agricultural Chemists, February 15, 1934.

perhaps know of a human feeding experiment that was interposed by chance up in the State of Massachusettts where the Massachusetts General Hospital had a large number of cases of lead poisoning. They began to notice a great many of those were non-industrial in origin. They selected 102 non-industrial cases, more or less at random, to see if they could pin the responsibility on anything in the food intake or otherwise.

They pinned the responsibility pretty well on the drinking water flowing through lead pipes and the daily intake of lead was rather small in some of those families. It has showed rather high incident of chronic lead poisoning with what a doctor would call gross symptoms, pallor, blue line on the gums, sometimes wrist drop and that sort of thing.

I think we can take it as pretty definite that there isn't any doubt about the danger of lead as a cumulative poison and about the mysterious way lead breaks out for no apparent cause at all when you have had a slight intake, for five, six or seven years. All at once, in painter's colic you get an outbreak, out of the bone marrow. It goes into the circulation. I don't know whether anybody knows why, but it is a dangerous sort of thing to be administering lead in small doses over a long period of time.

MR. HEADLEE: My point is why should we not have studies going on to establish this opinion of the toxicologists or destroy it?

MR. WHITE: I think it would be very desirable in order to convince the skeptics. I think it desirable in any new insecticide, hand in hand with the effect on the insect, to try to determine as near as may be the possible effect on humans. We can't go merrily along and wait until something happens. It is not a wise course, in my opinion.

THE STATUS OF CODLING MOTH CONTROL WITH INSECTICIDES[1]

By R. L. WEBSTER, *Washington Experiment Station, Pullman, Washington*

Those of you who have followed progress in codling moth (*Carpocapsa pomonella*) control during the past 25 years know well enough that over the country as a whole there has been an increased number of spray applications necessary during the season, that greater quantities of insecticide are used per 100 gallons of spray liquid, and that more material has been necessary per tree. We are rapidly coming to believe that codling moth control by means of insecticides is approaching rather definite limits and that supplementary means such as scraping and banding of trees and the greater utilization of biological control is absolutely necessary if fruit growers are to continue to produce apples reasonably free of worms. Washington fruit growers, because of their intense specialization in apple production (and the State produces about 20 per cent of the crop of the United States) have gone to extremes in thoroughness of spraying operations, yet even in the Pacific Northwest the codling moth appears to be keeping pace with all recent improvements in insecticides and in the use of various combinations for greater efficiency.

From time to time we have become enthusiastic over the possibilities of biological control of insect pests, yet I think most of you will admit when we analyze what actually has been done in case of the codling moth by such means that there is really very little in the way of tangible results on which we can depend for relief. A quarter of a century ago the State of Massachusetts was introducing various natural enemies from Europe to combat the gipsy moth. Much in the way of public support for such work has been available, and this expenditure has been worth while, yet the gipsy moth is still a factor of no small consequence in the New England states and one with which we must reckon for time to come.

The use of the chemically treated bands has been hailed as the greatest advance in codling moth control in recent years, yet there is good reason to believe that far more effective measures than scraping and banding of trees are necessary, in conjunction with good spraying practices, to reduce codling moth damage to a minimum. In our experimental orchard in Wenatchee, where intensive insecticide investigations have been under way since 1928, it was necessary this year to scrape and band all the trees

[1]Published as Scientific Paper No. 281, College of Agriculture and Experiment Station, State College of Washington.

in this 12-acre tract. Regardless of this, in Jonathans in the center of the orchard, thoroughly sprayed in 1933 with three pounds of lead arsenate per 100 gallons for six cover sprays, there was an average of 26.6 worms per 100 apples, approximately the same degree of control as in 1932 in this same variety. In other words, scraping and banding were not sufficient in addition to thorough spraying to enable us to hold our own. Not only this, but there was a short season in 1933 as compared to 1932 and one in which, generally speaking, worm control when efficient materials were applied was somewhat less of a problem than it has been for several years.

Whether we admit it or not, the codling moth is steadily becoming more difficult to control. In recent years we have felt that more effective spraying equipment, better timing of sprays, and the use of combinations of mineral oil and lead arsenate had enabled growers to keep pace with these ever increasing difficulties. Evidence to substantiate the idea that the insect is increasing in its resistance to insecticide treatment forces us to question whether we may not after all be engaged in a losing fight in the effort to hold control by spraying.

When we say that lead arsenate is the most effective single insecticide for the codling moth, it seems to be something of a confession of failure. Time and again we have had reports of varying degrees of control with the non-lead arsenicals. Always there is a fly in the ointment. Usually more or less injury to foliage has resulted from the non-lead arsenicals. Often these arsenicals have been reported as effective but most of these reports have emanated in regions where the codling moth is less difficult to handle.

While the worm damage for 1933 in the Pacific Northwest has been less severe than in 1932, the spray situation has been particularly difficult because of the necessity for meeting Federal restrictions on lead residue. It is quite apparent that the lead tolerance was placed on apples with little real knowledge either of the control problem or the difficulties involved in removing spray residue.

Following the promulgation of the 1933 lead tolerance, came insistent demands from our growers not only for information regarding the efficiency of various substitutes for lead arsenate, but also concerning the probable difficulty in washing fruit sprayed with these substitutes. Regardless of any kind of a tolerance, the principles of codling moth control had not changed. It was just as difficult to control worms as it was before any lead tolerance was established.

Until last spring practically no data were available on lead residue.

Information was lacking regarding the influence of mineral oil in the late cover sprays following heavy applications of lead arsenate earlier in the season, although previous studies had shown that a spray schedule of this kind often resulted in a difficult cleaning problem. To cap the climax, a tolerance on fluorine was established, although certain fluorine compounds had only recently been shown to be effective. Rumors as to the probable attitude of the Food and Drug Administration on the fluorine compounds held back many growers from using these materials. Furthermore, no figures were available on the probable amount of fluorine residue which one or more cover sprays would leave on the fruit.

At the Hood River, Oregon, meeting of the Northwest Association of Horticulturists, Entomologists, and Plant Pathologists, in July, 1933, many investigators expressed the opinion that, from the standpoint of both control and residue removal, the use of lead arsenate throughout the season in the long run involved the least practical difficulty. An attempt was made to rank insecticides other than lead arsenate in relative positions so far as their value for codling moth control was concerned, and it was generally agreed that nicotine-oil would rate first, fluorine compounds (especially cryolite) second, manganese arsenate third, and calcium arsenate fourth.

This relative position was guided by previous experimental work on the part of both Federal and State investigators. At the end of the season we now believe that this same rank still holds, with the exception that manganese arsenate has been less toxic to the worms than calcium arsenate. In giving out information regarding these two materials last summer, growers were warned that they should expect a less degree of control and that injury would likely occur. Both of these things happened.

NICOTINE-OIL.—Because excellent results had been obtained where the nicotine-oil combination was used in late cover sprays to replace lead arsenate, this combination was first in line in the attempt to reduce the lead load on the fruit. Even though the cost of the combination was regarded as excessive, it was assumed that there would be less lead to remove at the end of the season. According to data accumulated this year by the Washington Experiment Station, the lead load on fruit where three cover sprays of nicotine-oil were applied late in the season following lead arsenate was actually higher than that on apples sprayed throughout the season with lead arsenate and washed in the same solution.

Some of the most difficult cases of residue removal have been encountered where mineral oil in one way or another has followed lead arsenate.

While most of this fruit could be cleaned in a satisfactory manner it was often necessary to utilize both acid and alkaline washes and to increase the temperature to such an extent that injury to fruits often resulted. On this account we are reluctant to advise the use of mineral oil in late cover sprays either with nicotine or lead arsenate because of the difficulty in removing lead residue.

FLUORINE COMPOUNDS.—We know that certain fluorine compounds may be substituted for lead arsenate especially in late cover sprays. Control equivalent to that of lead arsenate may be obtained, especially when fluorine compounds are combined with fish oil or with mineral oil. When objection to lead residues was first raised, many growers turned to fluorine compounds as a way out, only to be met with a fluorine tolerance on the part of the Food and Drug Administration. Analyses by Federal investigators in the Northwest this year clearly indicate that not more than two applications can safely be made with any expectation of meeting the .01 tolerance on fluorine. Here again if mineral oil is used with a fluorine compound there will be difficulty in meeting the lead tolerance and the grower finds himself being thrown out of the frying pan into the fire.

CALCIUM ARSENATE.—Under conditions of heavy infestation calcium arsenate generally has been far less efficient than lead arsenate. I have before me a statement of the spray schedule of a large orchard in Indiana where three cover sprays of calcium arsenate were used, followed late in the season by a mineral oil spray. This grower reports 85 per cent of his crop lost due to the codling moth: a general average on all varieties. It would be unfair to charge all this to calcium arsenate, still the heavy injury occasioned by late worms must be largely credited to first brood larvae which were not killed by calcium arsenate early in the season.

Calcium arsenate apparently is sufficiently toxic if a fairly uniform deposit can be maintained during the season. There remains, however, the factor of injury, which must be controlled before apple growers can turn to calcium arsenate in order to escape lead residue.

There is good reason to believe that calcium arsenate may be adapted in some way for codling moth control. Investigations by James Marshall at the Wenatchee field laboratory of the Washington Experiment Station have given us some evidence in that direction. Encouraging results have been obtained where calcium arsenate has been used with metallic sulphates and hydrated lime to check injury to foliage. So far it seems entirely possible to obtain a degree of control practically equivalent to lead

arsenate. These investigations have not yet been carried far enough to warrant any general recommendations for the use of calcium arsenate.

Where calcium arsenate has been used throughout the season, acid washes have been generally effective in reducing the arsenic deposit.

MANGANESE ARSENATE.—Even though reports of worm control with manganese arsenate in various sections of the country seem to be well founded, results in the Northwest this year were most discouraging. Where equivalent deposits were present on fruit, comparing lead arsenate with manganese arsenate and fish oil on Romes, there were twice as many worms in the manganese arsenate plot. Laboratory studies indicated even greater differences. Where fish oil was added to both lead arsenate and manganese arsenate in the insectary there were three times the number of worms entering apples sprayed with the manganese arsenate.

ZINC ARSENITE AND ZINC ARSENATE.—There still remains some hope that zinc arsenite and possibly also zinc arsenate may be improved to represent an effective spray treatment. Here again is the factor of plant injury, which must be corrected. Again an arsenic deposit sufficient to check entering worms must be maintained, especially late in the season. In some of our experimental work in the Northwest we have obtained exceptionally high deposits with zinc arsenite which may in turn be difficult to remove.

LEAD ARSENATE.—After all is said and done, where growers are equipped with adequate washing machinery they will of necessity use lead arsenate in 1934 and do their best to meet the new .019 lead tolerance. Experiences over the whole country have shown that it is impossible to control codling moth without depending largely on lead arsenate. Where washing equipment is not available, the grower either will have to install such equipment or be forced to dispose of his apples within the boundaries of his own state.

It has been shown that high deposits are necessary to check the worms. In cases of severe infestation growers have not been able to do this with lead arsenate alone. The use of lead arsenate substitutes during 1933 has enabled the codling moth to become more firmly established than ever before in many an orchard. This is particularly true in districts where washing equipment was not available and where special efforts have been made to reduce the lead load by turning to other materials.

While mineral oil may be used early in the season and serve also as an ovicide, the same combination is ruled out in the late cover sprays because of residue complications. In case of fish oil we may be able to avoid residue difficulties but we cannot expect to use either mineral oil or fish

oil throughout the season without encountering some injury to foliage and fruit. Where fish oil is combined with lead arsenate the use of sodium silicate in the wash has ordinarily been quite sufficient to meet the present lead tolerance.

A fairly high deposit uniform in consistency may be maintained when certain spreaders are used with lead arsenate. Such usage so far as we have been able to determine has not led to any particular difficulty in residue removal.

The apple grower is certainly between the devil and the deep blue sea with regard to lead arsenate. No other single material has proved as efficient. Although combinations have given us approximately equivalent protection, these usually have led to removal difficulties of one kind or another. It is most unfortunate that the Food and Drug Administration should have placed a tolerance on fluorine at the same time that a lead tolerance was put into effect. Progress in pest control has in no way been aided by this branch of the Federal service.

MR. FLINT: I should like to ask if any tests were run with soy bean oil in place of fish oil.

MR. WEBSTER: We tested various vegetable oils. There was some injury with practically all of them. In the Northwest the growers expect to depend largely on lead arsenate with fish oil and to wash with sodium silicate. The number of cover applications depends on location—all the way from two or three to six. In the lower Yakima Valley, sometimes eight, sometimes ten. It is in the lower Yakima Valley, by the way, that the most difficulty has been encountered in lead residue removal.

THE STATUS OF CODLING MOTH CONTROL IN THE PACIFIC NORTHWEST

By E. J. NEWCOMER, *U. S. Bureau of Entomology*

Control of the codling moth (*Carpocapsa pomonella*) in the Pacific Northwest is probably as difficult as anywhere in the United States. As evidence of this, many growers consider it necessary to apply six to nine cover sprays in their orchards. In experimental work, six thorough cover sprays have not always sufficed for adequate control. There are districts in which it would probably be wiser to give up raising apples than to attempt the control of this insect.

In 1933, a short season simplified the fight somewhat, and in spite of considerable uncertainty as to the spray program to be followed, most

growers produced a greater percentage of clean fruit than they had during the preceding two seasons. In this they were aided to some extent by a rather general use of chemically treated bands, about 30 per cent of the older orchards in the vicinity of Yakima and Wenatchee having been banded. Owing to adverse financial conditions, several thousand acres of apple orchards were not sprayed at all, and since in these orchards the fruit becomes almost completely wormy in a single season, the total codling moth population in the region is probably larger than it has ever been.

Thanks to improved methods of cleaning, about 97 per cent of the fruit washed up to December 1 came under the present lead tolerance of of 0.02 grain per pound. The 3 per cent not coming under this figure, representing, on the basis of the total crop, probably 750 cars of fruit, had to be rewashed or disposed of to by-products plants. Although many growers and shippers have attempted to attain the proposed figure of 0.014 grain of lead per pound when cleaning their fruit, about 30 per cent of the total crop or 7,500 cars has not been below this figure.

Very good control was obtained in some cases this season with lead arsenate, alone or with a spreader. In many cases it was necessary to use oil emulsion with the lead arsenate, and if used late, this made cleaning very difficult. Many growers used the nicotine-oil combination for the second brood, with satisfactory results, but this interfered somewhat with cleaning the fruit, especially if heavy applications of lead arsenate had been made earlier. A few growers used this combination after the first cover spray with fair success, but such a schedule is expensive, and in many instances it cannot be employed, owing to injury by the oil.

Cryolite (sodium fluoaluminate) was rather widely used for second-brood sprays, with fish oil, mineral oil, or soap, and the results with it were almost invariably good. However, difficulty has been experienced in removing heavy residues of fluorine from the fruit, although removal of the lead arsenate previously applied is not interfered with. There is also more danger of injury to the fruit from the traces of fluorine and washing chemicals left on it if it is not rinsed quite thoroughly. One of the most satisfactory spray schedules used consisted of lead arsenate and fish oil for the first brood, and cryolite and fish oil for the second brood. This controlled the codling moth very well and the fruit was not particularly difficult to clean.

Very little calcium arsenate was used by the growers, as they had no confidence in it. Control was poor, as was also the case in most of the

experimental work with this arsenical. Injury to fruit or foliage was negligible, even though no lime was added to the calcium arsenate. A much greater quantity of manganese arsenate was used, as the growers believed it would be safer and more effective. It turned out that the reverse was true, control being poorer in comparative tests, and arsenical injury being in some cases rather severe. No particular difficulty was experienced in removing either of these arsenicals with acid solvents, but alkalies proved to be ineffective.

CODLING MOTH CONTROL BY THE USE OF INSECTICIDES IN MICHIGAN, OHIO, INDIANA AND ILLINOIS

By W. P. FLINT, *Urbana, Ill.*

As a general statement of the results of the 1933 experimental work on insecticide control of codling moth (*Carpocapsa pomonella*) in Indiana, Michigan, Ohio and Illinois, we may say that lead arsenate was superior to any other material used. In both Indiana and Illinois lead arsenate alone was very little and in some cases not any superior to calcium arsenate. Practically the same was true for Michigan. In both Ohio and Illinois lead arsenate alone in very heavy infestations did not give a satisfactory control. The effectiveness of lead arsenate was increased throughout this area by the addition of certain oil sprays, particularly in the last first brood and early second brood sprays. For Illinois alone the addition of certain summer or dormant oils to the lead arsenate sprays for late first brood and second brood have, during the past three years, reduced by more than half the percentage of wormy fruit, compared with lead arsenate used alone.

Taking up the states separately:

In Michigan as reported by Mr. Hutson tests have been made with calcium, zinc and magnesium arsenate. When compared with lead arsenate, other arsenicals gave a significantly lower control throughout, without damage to vigorous trees. The same statement can be made of such contact insecticides as oil-nicotine and nicotine tannate when an equal number of applications were made. With an increased number of applications the nicotine-oil combinations approached the percentages of control obtained with lead arsenate. Nicotine tannate was no better than oil-nicotine although the results with this material were somewhat better than those obtained in previous years. In growers tests the marked difference in results can be attributed largely to personal factors.

In Ohio, due to seasonal conditions rather than change in spray programs, codling moth was much more severe than usual.

Field trials determined the relative efficiency of the following arsenicals in the order named: 1, lead; 2, zinc; 3, manganese; 4, calcium; 5, magnesium. No growers reported burning with calcium arsenate.

The relative efficiency of non-arsenical insecticides as substitutes in late sprays were: 1, natural cryolite-oil; 2, oil-nicotine; 3, barium fluosilicate-oil; 4, oil-oleic acid; 5, summer oil; 6, nicotine tannate. Natural cryolite, oil-nicotine and barium fluosilicate-oil were very close to lead arsenate in efficiency.

In Indiana the best results of the season were obtained with lead arsenate throughout the first brood sprays followed by second and third brood sprays of 2 per cent summer oil plus 10 per cent oleic acid in the stock. This combination gave negligible spotting of the fruit and very slight foliage injury.

Lead arsenate alone throughout the season did not give a satisfactory control and caused a heavy drop of foliage.

Of the 5 standard brands of calcium arsenate tested, none gave satisfactory control. Zinc arsenate gave good control throughout the early season but dropped later. It was felt that satisfactory control could have been obtained had the number of applications been increased during the late season.

Barium fluosilicate gave excellent control but severe injury, causing a decrease in the size of fruit, partial defoliation and severe cracking of Jonathan.

Nicotine tannate gave satisfactory control with moderate to severe injury on Winesaps and Jonathan and caused considerable discomfort to the men applying it.

Cuprous cyanide was received too late for regular tests but showed some promise. In Illinois it was inferior to lead arsenate but one of the most promising of the new materials.

In Illinois the best results in field tests were obtained with the full season spray of lead arsenate with oil in the late first brood and all second and third brood sprays. This program carried out for the full season in a heavily infested orchard in southern Illinois where codling moth is as abundant as any place in the middle west, reduced a 32 per cent infestation in 1932 to a 4 per cent infestation in 1933. The residue was excessive but has been removed satisfactorily. Storage tests are not yet completed.

Seven brands of calcium arsenate were tested, all of which gave burning under certain conditions. Comparable tests of calcium and lead ar-

senate showed calcium arsenate practically equal to lead in toxicity. Superior in a few cases.

The oil-nicotine combinations gave inferior control when used in second brood unless the number of applications was increased over those of lead arsenate.

Zinc arsenate gave good results but not quite equal to lead arsenate. This material looks very promising when combined with oil.

Certain of the fluorine compounds gave better results than has been obtained in any previous season. These were used for second brood only. It is evident that fluorine materials must be used with caution on Jonathan as this variety seems very susceptible to fluorine injury.

STATUS OF THE CODLING MOTH IN THE NORTHEASTERN STATES

By S. W. HARMAN, *Geneva, N. Y.*

The codling moth (*Carpocapsa pomonella*) has been steadily increasing in the northeastern states during the past decade. At the beginning of that period there were very few districts in which the insect demanded special attention. Southern New Jersey was perhaps first to detect indications of increasing difficulties in combating the pest by the usual spray procedures. A few years later parts of Pennsylvania and the fruit-growing counties of western New York experienced similar conditions. In general, however, the petal fall and a few summer sprays usually afforded sufficient protection against the codling moth in New England and the adjoining states.

Today most of this area recognizes the codling moth as a major apple pest and in a few sections the losses have reached such proportions that an acute situation confronts the apple industry. Because of the variability in the degree of infestation in different districts, control measures range from as few as one or two summer sprays following the petal fall application to a program in which sprays are applied every ten days during the periods of codling moth activity. In the more seriously infested districts supplementary practices, such as banding, pruning, thinning, orchard and packing house sanitation, etc., are now being considered as necessary adjuncts to the regular spray program.

Areas where the pest has caused excessive losses are fairly well defined. Southern New Jersey in all probability presents the most serious situation. The south central counties of Pennsylvania and the western New York counties of Niagara, Orleans, and Monroe are experiencing diffi-

culties of a similar character. The problem diminishes to the north and eastward. In the Hudson River and Champlain Valley districts three summer sprays following the calyx are the maximum requirement. The New England states report minor problems about comparable with the Hudson River Valley. The State of Maine rarely experiences injury exceeding one per cent of the total crop.

There is considerable territory in these northeastern states in which the codling moth is not a serious problem, but, on the other hand, the apple maggot is widely distributed thru this region. In general, this insect appears to be at its worst in the sections where the codling moth is of little concern, and altho July sprays may not always be required for the latter, they are usually necessary to combat the maggot.

Recent work in New York with the newer and more promising insecticides continues to show lead arsenate as the most reliable single material for combating the codling moth. Its efficiency, when tested in heavily populated orchards, was noticeably increased when used at double the standard strength and also when combined with an oil. The combination of nicotine and oil has given most promise as a substitute.

Calcium arsenate was used extensively during the past season in eastern New York and New England. Altho very satisfactory from the residue standpoint, the efficiency of this arsenical when under test in orchards with serious codling moth infestations was noticeably below that of lead arsenate. It gave commercial control of apple maggot and the lighter infestations of codling moth, however, the danger of injury to fruit and foliage was a constant threat that often materialized.

In those sections where extensive summer spraying is practised the dry cleaners and washing machines are rapidly passing the novelty stage. In parts of New Jersey fruit cleaning has become an accepted practice among apple growers, there being some 47 washers in use during the past season. In New York the number of washing machines increased from 3 to 21 during the last year, the majority being located in the western fruit counties. Pennsylvania also recognizes the necessity of washing equipment in the more seriously infested sections.

The washing machines have, to date, been satisfactory, and in general the hydrochloric acid bath has cleaned fruit to meet the tolerance provided it was washed soon after picking. When increased quantities of lead arsenate or the combination of oil and lead arsenate were used in the second brood sprays the cleaning process was more difficult.

The McIntosh is a very popular apple in New York and New England, and as this variety requires extreme care in handling, the possibility of any further operation that may subject the fruit to even the slightest

bruising would meet much disfavor. Up to the present time the majority of growers have not found it necessary to clean their fruit, and it is evident from the general feeling that they will not take kindly to such a requirement. However, unless more normal seasonal conditions soon change the status of the codling moth or satisfactory lead arsenate substitutes are found, fruit cleaning may soon become a necessary practice in most of our packing houses.

THE STATUS OF THE CODLING MOTH CONTROL IN THE SHENANDOAH-CUMBERLAND FRUIT REGION

By W. S. HOUGH, *Winchester, Virginia*

During the past four seasons the codling moth (*Carpocapsa pomonella*) population has increased in the Shenandoah-Cumberland Valley fruit belt. The outbreak of 1933, however, eclipsed any that the writer has observed in 13 years of residence in the region. Among the principal factors contributing to the increase in codling moth injury were: (1) the abbreviated spray schedule followed for eight years by most growers in an effort to avoid removal of excessive arsenical residues by washing the fruit at picking time, (2) growers have for the past three years found it necessary to reduce production costs, including such items of expense as spraying and replacement of worn-out spray equipment, and, (3) the substitution of calcium arsenate for lead arsenate in critical cover sprays for codling moth control in 1933.

In Virginia and West Virginia the state department of agriculture sends inspectors into all orchards to collect samples of the leading commercial varieties for a chemical analysis of the spray residue on the apples at picking time. Experience of the past several years indicates that the best sprayed orchards can receive the petal-fall and two cover sprays of lead arsenate, applied about 3 and 5 weeks after the petal-fall stage, without exceeding a lead residue of .019 gr. per pound of fruit at picking time. In other words, our best growers cannot apply lead arsenate after June 10 or 15 without running the risk of exceeding the lead tolerance for 1934.

General orchard clean-up has been urged, including banding next June. Orchardists will be advised to use lead arsenate from early May to late July or even in early August and then prepare to wash the fruit. Growers in certain districts where the codling moth has not been a problem and those who are financially unable to prepare to wash their fruit will either quit spraying the middle of June or else use calcium arsenate with Bordeaux mixture in later sprays.

THE CODLING MOTH SITUATION IN ONTARIO

By WM. A. ROSS, *Vineland, Ontario, Canada*

The requirements for codling moth (*Carpocapsa pomonella*) control in Ontario vary to a very considerable extent, due primarily to variations in climate, and the extent to which local temperatures and probably wind conditions are influenced by latitude, elevation and proximity to the Great Lakes.

LATITUDE—In the more northern sections, *e.g.*, along the north shore of Lake Ontario and in the Georgian Bay district, the codling moth is much less injurious and more easily controlled than in the southern districts of the province.

ELEVATION—The effect of elevation is well illustrated in the Niagara fruit belt, where the insect is distinctly less troublesome on top of the Niagara escarpment (approximately 350 feet above lake level) than it is below this so-called mountain.

PROXIMITY TO THE GREAT LAKES—The influence of a great body of water, such as Lake Ontario, is clearly shown in the Niagara district by the fact that the moth is much more difficult to control in orchards even one or two miles back from the lake, than it is in plantings immediately on the lake shore.

Other factors, of course, play a part in creating still more local variations in the codling moth infestation, such as, orchard slope, proximity to packing houses, lack of sanitation, etc.

In view of the foregoing, it is apparent that no one set of recommendations for codling moth control, can be made for the whole province. Roughly, however, from the point of view of control requirements, Ontario orchards may be divided into three classes. In the first class, which includes the majority of orchards in the colder districts, moth injury may be kept down to small proportions in most seasons by applying a calyx spray annually. In the second class, we have orchards which normally require one cover spray in addition to the calyx application; and in the third class are orchards where it is necessary to apply a *minimum* of two cover sprays. The prevention of serious "side-worm" injury has not been difficult in classes one and two, and should be still less difficult now that three post-calyx sprays are being generally applied for apple maggot and scab control. The orchards in class three, however, constitute a problem, largely because in seasons especially favorable for the codling moth, when two cover sprays (three including the "small apple spray," which is applied primarily for scab control) are inadequate,

the owners of such orchards are liable to find themselves "between the devil and the deep blue sea"—the devil being excessive side-worm injury and the sea the arsenical residue problem. Under such conditions not being equipped to wash fruit, they are apt to omit one or more extra arsenical applications necessary for control. The problem in class three pretty well boils down to this: Would it pay the owners of such orchards to install washing machines to take care of abnormal codling moth conditions, or would it be more economical, in the long run, to take an occasional licking from the insect? I must confess we do not know the answer.

From all points of view lead arsenate has proved to be more satisfactory for combating the codling moth than any other insecticide. Oil-lead arsenate is more effective than the arsenical alone, but the use of this combination is attended with some risk, and is entirely barred on the variety Ontario, the fruit of which is extremely susceptible to oil injury.

CHAIRMAN PARROTT: In view of the comment by Mr. White of the Food and Drug Administration I think it is perfectly clear to all of us that one of the important goals that the entomologists have to keep in mind is the discovery of a non-lead, non-arsenical compound. I was reading the other day that there are some 250,000 organic compounds and they are being discovered at the rate of 20 a day.

The entomologist needs to know something of the merits of these materials for control of injurious insects. Dr. Headlee presents a paper indicating to what extent they can be used as insecticides. I hope he has one which is efficient and can be recommended. Mr. Headlee!

MR. HEADLEE: Before I start on this little presentation, I can't see any reason why we should not largely conquer this codling moth in the dormant season. When we come to ten cover sprays we are putting on enough cover sprays to knock the trees out. I think we have abundant evidence in New Jersey this year of too many sprays being very deleterious to the trees. We must get away from the requirement of so many sprays. Administer the first blow in the dormant season and the second smash on first brood, and we will get somewhere.

TO WHAT EXTENT MAY ORGANIC INSECTICIDES BE USED AS SUBSTITUTES FOR ARSENICALS[1]

By THOMAS J. HEADLEE, PH.D., *Entomologist, New Jersey Agricultural Experiment Station*

It is assumed by the writer that the question stated in the title of this paper should be answered from the standpoint of available facts but with due regard to the symposium subject of which this paper is merely a sub-title. This symposium is concerned with the solution of the spray residue problem, presumably wherever it occurs but primarily connected with fruit and vegetables.

Other speakers will doubtless have pointed out that to a large extent the spray residue problem can be avoided by the proper timing of spray applications and that such residues where they exist are susceptible of removal.

This paper is concerned with the organic substances that may be used instead of the arsenicals and other materials, which leave residues that must be removed. These organics include tobacco, pyrethrum, derris, petroleum oils and pine oils. Inasmuch as these substitutes are designed to avoid the accumulation of residues that must be removed, they must either disappear from the fruit and edible portions of the plant before time for marketing arrives or they must be essentially non-toxic to man when used in connection with food materials. Tobacco and its extracts are more or less toxic to man when taken through the mouth. Pyrethrum, derris, petroleum oils and pine oils are not essentially toxic to man when consumed in connection with food except as they have not been properly processed or are taken in large quantities.

TOBACCO.—The active toxic principle of tobacco has long been recognized as nicotine although there is some evidence to indicate that certain of the resinous materials present in the tobacco plant may have some toxic qualities. The writer's consideration of tobacco will be limited to nicotine.

It has been clearly shown by many workers that nicotine in a liquid or gaseous form is destructive to insects, even those which are commonly designated as chewing insects. Beginning with Lovett (7) working in the northwest various workers have shown that nicotine sulfate mixed with oil and applied to apple trees during the period of entry by codling moth larvae is an effective toxic agent against that insect, not only in the larval form but in the later stages of the eggs. The principal disadvan-

[1]Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

tage of nicotine in this form appears to be its inability to remain for a long period of time in toxic doses on the fruit and foliage of the apple tree.

A natural step in overcoming this lack of persistence was to produce nicotine compounds in liquid, paste or solid form. Nicotine oleate is a liquid paste while nicotine tannate is a solid. Nicotine oleate has been shown to have considerable toxicity against a number of different insects but has not been developed extensively for the codling moth problem.

Nicotine tannate, on the other hand, which is the result of a combination of free nicotine and tannic acid, has received a considerable amount of attention as a toxic agent for control of the codling moth. Working in the summer season of 1929, Headlee, Ginsburg and Filmer (5) showed that nicotine tannate kills codling moth but loses about three-fourths of its nicotine within a ten-day period. Filmer (3) working in the season of 1930 made a comparison of nicotine tannate and lead arsenate against the codling moth and demonstrated that when a sufficient coating of the former material is maintained on fruit and foliage it kills codling moth as well as lead arsenate. Moore (8) working in the summer season of 1931 showed through the medium of laboratory tests, that nicotine tannate was consistently more toxic to codling moth than lead arsenate, killing more larvae and permitting fewer entries than lead arsenate. In the course of this work Moore also showed that nicotine tannate killed three or four day old eggs of the codling moth. Headlee (6) reporting on orchard block work done by Thompson in the season of 1932 showed that nicotine tannate when used for the same number of applications (7) as lead arsenate or oil-lead arsenate gave a better control of codling moth than was obtained with lead arsenate or oil-lead arsenate. Driggers and Pepper (1) working with orchard blocks in the summer of 1933 showed very decidedly better control with nicotine tannate than with lead arsenate or oil-lead arsenate.

Thus it appears from these facts, chiefly obtained in New Jersey, that nicotine tannate is decidedly more effective than lead arsenate or lead arsenate-oil. A considerable portion of the data from the other parts of the country is not in agreement with the facts stated above.

Possibly an attempt to offer an explanation of these differences would be worthwhile. In the first place, it has been definitely shown by various workers in New Jersey that nicotine tannate disappears from the foliage with the passage of time, that approximately 75 per cent of the nicotine disappears in a ten-day period, that rainfall decidedly expedites this disappearance and that strong alkalies destroy the efficiency of nicotine

tannate. Too infrequent applications and the presence of frequent rainfalls would, therefore, result in failure to secure control with nicotine tannate. Likewise, the use of excessive alkaline spray waters or the inclusion of strong alkali spray materials would prevent success with this material. It seems that failures to obtain control with nicotine tannate are due to too infrequent applications, rainfall wash-off, the use of excessively alkaline waters or the inclusion of strong alkali spray materials.

This quality of the disappearance of the toxic agent from the fruit is a matter of great advantage from the standpoint of the accumulation of deleterious residues which must later be removed but too prompt disappearance is a great disadvantage. In 1933 Driggers and Pepper (2) discovered that the use of bentonite sulfur which has not only excellent fungicidal but truly remarkable adhesive properties, when used with nicotine doubled the length of the toxic period.[3] It seems that the bentonite in the bentonite sulfur fixes the nicotine as it is freed from the nicotine tannate by weathering and holds it on the foliage and fruit of the apple tree. In recent work, as yet unpublished, Moore (8) has shown that the toxicity of nicotine is sufficiently greater for codling moth than the toxicity of arsenate of lead to open the possibility of the use of a reduced dosage.

The primary factor in the way of a widespread use of nicotine in a liquid or solid form against the codling moth in the place of arsenicals is its greater cost. The cost factor can be reduced by the use of fewer sprays or the use of smaller dosages of nicotine. A way towards the reduction of cost of nicotine treatments has been indicated through Driggers' results in the year 1933 where he was able to maintain a toxic dose of nicotine on fruit and foliage through the combination of nicotine tannate and bentonite sulfur and it is to be hoped that Moore's effort toward the reduction of cost by showing how reduced charges of nicotine may be made sufficiently toxic will be continued to their ultimate goal. The question of cost includes not only the cost of material and the expense of applying it but must be considered from the standpoint of the clean fruit produced by the process. It has been distinctly shown that more clean fruit can be produced by use of nicotine tannate where it is properly applied and maintained on fruit and foliage than can be produced by the use of lead arsenate with an equal number of treatments. This is a phase of the cost question usually overlooked by workers when

[3]At this point I want to mention that bentonite sulfur is a combination at the melting point of sulfur between sulfur on the one hand, and bentonite on the other, bentonite being clay. The adhesive properties of the resulting compound are entirely beyond the adhesion of the two components.

comparing the relative cost of nicotine and lead arsenate. Furthermore, nicotine tannate has been distinctly shown to effect a very remarkable control of the late broods of rose leafhopper affecting apple orchards. This performance must necessarily be taken also into consideration when figuring the value of nicotine tannate as an orchard spray.[2]

PYRETHRUM.—The recognized toxic principles of pyrethrum are pyrethrin I and pyrethrin II. It has been shown that these toxic principles have a certain limited amount of stomach poison effect and much contacticidal effect but it has likewise been shown that exposing them to bright sunshine in a thin layer on the surface of fruit and foliage results in an almost total destruction of their toxic quality within a period of a few days. It is obvious, therefore, that until some method is found by means of which the toxic qualities of the pyrethrins can be retained over a longer period of time they cannot be used as satisfactory substitutes for arsenicals in treating orchards and vegetable plantings.

On the other hand, if these principles are not extracted but left in the pyrethrum dust as it comes from the grinders, the persistence extends over a considerably greater period but sooner or later the toxic qualities of even the pyrethrum dust are destroyed.

The only opportunity for using pyrethrum either in its extracted or in the ground dust form as a substitute for arsenicals must be found in the practice of destroying the chewing insects by contact at the time of application or over a short period thereafter.

DERRIS.—Early studies indicated that the toxic principle of derris, as well as cube and various other plants of a similar character, was rotenone. More recent investigations, however, have demonstrated that in dealing with derris, rotenone does not represent adequately the toxicity of the ground root or of the complete extract.

Resinous material in the ground root and the extract accounts for much of its toxicity to insects. Derris extract is not only a highly toxic contacticide but has very considerable stomach poison destruction ability.

Like pyrethrum the active principles of derris are readily destroyed by exposure of them in extracted form or even in a dust form to bright sunlight and air. Again like pyrethrum it has been shown that they persist for a considerably longer time when left in the un-extracted state in the ground root.

[2]At this point I want to digress just a moment to point out that it is quite possible that the combination of nicotine sulphate and bentonite sulfur will give a compound as toxic as the nicotine tannate and bentonite sulfur has been shown to be, and will be materially cheaper. However, we do not have that point block tested and we are not sure that such will be the case although it looks very much that way.

In general, it seems obvious that until such time as measures are found by means of which the persistence of the toxic principles of derris can be maintained over a much longer period than is now possible, the use of it as a substitute for the arsenicals cannot be recommended except as the destruction of the chewing insect is obtained immediately after application or over a few days thereafter.

Serious as is this effect of sunlight and oxygen upon the toxic principles of pyrethrum and derris it nevertheless has been proven possible to use them extensively upon vegetables for the performance of cleaning the insects off the plants when the treatments must be made within a dangerous time limit before harvesting and sale. Derris dusts are probably today the most promising substitute for arsenicals upon vegetable plants, the above ground portions of which are intended for human food.

PETROLEUM OILS.—Many petroleum oils and many of their fractions are extremely toxic to insects whether of a sucking or chewing nature but the effect in every case is contacticidal. Toxicity of petroleum oils appears to be fundamentally dependent upon the nature of the hydrocarbons in their composition and upon the degree of saturation which they exhibit. Other things being equal, the greater the amount of unsaturates, the greater the destructive power of the oil but there are petroleum oils carrying the same degree of unsaturation which are definitely different in their toxicities to insects. Unfortunately, there is nothing much fundamentally known about the structure of the petroleum hydrocarbons above gasoline so users of petroleum oils for summer sprays are compelled to depend upon the degree of saturation as a safety limit. Still another quality of petroleum oils enters in as a factor affecting the toxicity of these oils. The higher the volatility the less toxic are the oils because their penetration is not so deep and their period of retention is not so long. In general, high volatility oils are low in viscosity and low volatility oils are high in viscosity. Low viscosity promotes rapid entry of oils into foliage and fruit and tree tissue in general, while high viscosity slows up the period of entry but permits retention for a longer period, resulting in perhaps as great or greater penetration than that which would occur with a low viscosity oil.

Ginsburg (4) and many other workers have shown that the use of summer oils on foliage and fruit has a deleterious effect upon the normal physiology of the plant, may produce immediate and serious injury which is recognized as burn and leaf drop or may produce an apparent stimulation which later results in a decreased fruit-bearing ability of the plant thus treated.

Petroleum oils, as they are used during the growing season today, even when highly refined, are likely to produce deleterious effects if repeated with great frequency and accumulative deleterious effects if continued from year to year. So long as these oils, no matter how highly refined, penetrate the fruit and foliage and other parts of the plant there is no doubt that they produce a more or less deleterious effect. Relief must be sought either by utilizing petroleum oils that are so viscous that they form a solid at ordinary temperature, such as the various waxes, and so cannot enter the foliage and fruit or by seeking an oil of such high volatility that it has no opportunity to remain long enough to produce a deleterious effect on fruit and foliage. The former will undoubtedly remain upon the foliage and fruit for longer periods of time but will be extremely inactive on plants and inactive against insects. The latter will have reduced efficiency against insects as well as increased safety on plants because the volatility which protects the plants will likewise affect the insect results. The only chance to render these materials efficient against chewing insects is to incorporate in them a material non-toxic to man or a material of the type which will disappear before the fruiting portions are to be sold and consumed. These are promising lines of attack.

PINE OILS.—Pine oils range from highly viscous to extreme low viscosity. Resinous materials are usually responsible for high viscosity and such materials are apt to be highly toxic to plants and to foliage. It is, therefore, possible to use in summer spraying only those fractions of pine oil of low viscosity and high volatility. Even here the rapid disappearance of the oil, giving protection to the plants, likewise renders it inefficient against the insect. The only opportunity to use such a high volatility oil is to put with it an insecticidal agent which can be well distributed by it and left upon the foliage and fruit when the oil volatilizes.

SUMMARY AND CONCLUSIONS

(1) As present knowledge now stands, the only organics that can be considered for use as substitutes for the arsenicals must be looked for in tobacco, pyrethrum, derris, and other plants carrying rotenone, petroleum oils and pine oils.

(2) Enough work has been done upon nicotine to show that certain solid forms can be used with greater destructive effects upon codling moth than can arsenicals.

(3) That present knowledge indicates ways and means by which solid forms of nicotine can be used, everything considered, as substitutes for the best arsenical for codling moth control and the indications

are that developments are at hand by means of which solid forms of nicotine can be used on a competitive basis with lead arsenate.

(4) That while pyrethrum and derris can be used for destroying chewing insects the period covered by their activity is too short, but at that they offer the best available substitute for arsenicals on certain vegetable plants.

(5) That oils, whether from petroleum or pine source, must, for the sake of safety on plants, be made so inactive that they themselves are not effective insecticides, but that it may be possible, by incorporating insecticides in them, to utilize them as substitutes for arsenicals.

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Mr. Headlee: It is customary according to the Chairman when the paper has been finished, to say what the particular region represented is going to do about recommendations. We intend to recommend lead arsenate for apple protection in New Jersey. We will also recommend nicotine tannate as a substitute but we will recommend that bentonite sulfur shall be used with the nicotine tannate. The only way we can meet the situation is to have a special spraying schedule for persons or growers whose fruits are seriously threatened. So we will put out two spraying schedules, the one a general schedule which applies all over the state, and the other is the special spraying schedule which applies to certain orchards in which codling moth is severe.

We will recommend concentration of the cover spraying on the first brood, and not more than two applications on the second brood. We are convinced that the primary reason we are having trouble is because of failure to cover and keep covered the fruit and foliage during first brood; we get too many first brood worms through.

Sometimes if the spraying is done from the ground, it is in the top of the tree and if the spraying is done from a tower entirely, it is around the bottom of the tree that the worms succeed in getting through. We consider an average of 175 or 180 worms alive in spring per tree a heavy infestation and a condition that will give plenty of trouble.

Where codling moth is very bad we shall recommend winter treatments, scraping rough bark off the tree, pine oil in all cracks and crevices, prunage scars, cankers where the codling moth winters over. Our results in the past have shown practically 100 per cent of the codling moth in the orchard winters over on the tree. The only other chance is orchard debris, used fruit containers, storage houses here or there or packing sheds not properly cared for. (Applause.)

MR. HODGKISS: I would like to add a little bit to what Mr. Headlee says. I entirely agree with him. From what I have seen of Pennsylvania, the real cause for our infestation is not due to the fact it cannot control the codling moth. It is due to the let-up in the practice by the people themselves over a period of years and they got caught during the heavy infestation of 1930.

The codling moth under our conditions, I believe, is comparatively easy to control if we can get the fruit growers to spray the trees properly, using the proper methods, the correct dosages and in that way getting away from spray residues and to use supplemental measures during the winter and spring in order to kill or clean up the hang-over of the codling moth.

MR. CHAPMAN: I'd like to add something to Mr. Headlee's statement of the nicotine preparation that might be of interest. As Mr. Webster said in his talk, when we start deviating from the use of lead arsenate against the codling moth, we usually find there is at least one fly in the ointment. In this case, it is possible this particular fly may be the apple maggot fly. We are thinking of using the nicotine preparation. The past season we had several orchards treated with nicotine tannate and one with nicotine and an activator against the apple maggot.

In both of these orchards under the conditions of the test the nicotine preparations did not hold the apple maggot. There was an increase over infestation in 1932.

CHAIRMAN PARROTT: We turn to a third phase of this symposium, that is the situation with regard to the vegetable industry. I will call for the first paper by W. H. White.

Mr. W. H. White presented a paper entitled "The Situation in the Vegetable Industry with Respect to the Use of Arsenicals and Arsenical Substitutes." It was withdrawn from publication.

MR. GINSBURG: Mr. Chairman, I'd like to ask Mr. White upon what basis would he recommend derris dust containing 1½ per cent rotenone. Is 1 per cent not enough or has it been shown that 1½ per cent is necessary to kill cabbage worms?

MR. WHITE: These recommendations, based on results last year, were basic, and we did not know exactly where to start with the dilutions. We used derris containing 1 per cent rotenone and ½ per cent and 2 per cent, and there is variation in the results so we decided to recommend tentatively dust containing 1½ per cent.

MR. GINSBURG: I would like to add, if I may, 1½ per cent dust is very expensive, as we know. Recent investigation by several investigators has shown rotenone is not the main toxic principle as far as chewing insects are concerned. As a matter of fact, derris from which all rotenone has been extracted has proven to be almost as toxic or just as toxic to cabbage worms particularly as derris containing 1½ or more per cent rotenone.

THE SITUATION IN THE VEGETABLE INDUSTRY WITH RESPECT TO THE USE OF ARSENICALS AND ARSENICAL SUBSTITUTES

By H. C. HUCKETT, *Riverhead, N. Y.*

During the past decade there has been a significant increase within the United States in the number of shipments of vegetables in interstate commerce that have been held up for inspection owing to the possibility of carrying excessive quantities of arsenical residue. The trouble flared up in the celery industry of Florida about nine years ago and has now again come to the front in certain cabbage and cauliflower growing areas. Between July 1932, and June 30, 1933, two hundred and forty-one lots of fruits and vegetables were confiscated on account of excessive amounts of arsenical residue, and of these 74 consisted of vegetables. Few, it may be thought, in proportion to the whole, but quite sufficient to demoralize the market if it were to continue.

The use of arsenicals for chewing insects on vegetables was tried out

by Riley as early as 1870, and ever since entomologists have recognized more or less the risks involved in the use of such materials on vegetables. However it has been generally accepted that washing and the removal of the older leaves during the normal preparation of food for cooking precluded any possibility of danger to human health. That there was actual danger from poisoning is evident by the guarded statements made concerning the use of unwashed or untrimmed vegetables as feed for livestock. The effect of such practices in insect control under modern conditions of marketing produce has only just recently been brought to light by what has happened during the past few years. With leafy vegetables such as cabbage, cauliflower, collards, celery, and possibly sweet corn, much of the crop is often marketed in a roughly trimmed condition and would thereby be largely exposed to the same risks that such material might carry if fed to live stock. The supposition that much of this roughage would be eliminated in the preparation of the vegetable for human food and that therefore the final product can do no harm has largely been dispelled by recent findings in some of the best hotels in New York as well as in the restaurants of the poorer districts, where often the whole vegetable is used in one form or another. Be this as it may, the fact remains that produce in such condition when offered for public sale is liable to come within the jurisdiction of the Federal food and drugs act owing to carrying excessive amounts of arsenical residue.

It might be pertinent to suggets at this time a few of the causes that may have contributed to the present situation with vegetables relative to the arsenical residue problem, a situation which undoubtedly has been in existence for a longer period than we realize. There has been such a renewed and intensive study of late years into the full significance of what constitutes poisoning among insects that for the moment such a condition of affairs has temporarily eclipsed or obscured the importance of its meaning in relation to human health. Similarly there seems to be no positive conception among many entomologists regarding the relationships between applications of arsenicals and the resultant residue at time of harvest for different types of crops. There has been a significant increase in the use of arsenicals during the past decade from 14 million pounds in 1919 to 58 million in 1929, in which the vegetable industry undoubtedly has had its full share. There has been a tendency under modern conditions to do more dusting and less spraying of vegetables, with resultant increase in the lodgment of residues on certain parts of the plant. And, with the recent trend to specialization in vegetable and truck farming, the matter of insect control has become more pressing in its demands.

Certain of the above suggested causes are undoubtedly capable of easy removal whilst others are not. But the question may be properly raised whether having corrected certain deficiencies, will be any nearer solving the practical difficulties pertaining to the use of arsenicals as it relates to the vegetable industry. In the last analysis the chief difficulty to be overcome by those involved is to restore confidence in the buyer and to allay public suspicion, a problem which rests in part within the domain of farm management.

The practice of using arsenicals for insect control on vegetables has long fallen into disrepute in most European countries as carrying too grave risks. This attitude no doubt will be somewhat modified by the recent establishment of the Colorado potato beetle in France. The attitude in America until very recently has almost been the very opposite, if for no other reason than that our experience has led us to believe that arsenicals could be used with safety by the public for purposes of insect control. With an apparent change or modification in attitude with regard to the question of the use of arsenicals that is now in evidence, there will undoubtedly be renewed attempts to correct or control the residual effects of arsenical applications to comply with government regulations, or, better still, fresh efforts will be made to find and develop insecticides that are nonpoisonous to human beings, and that will effectually dispose of the need for arsenicals where such are required.

Although long advocated in a sort of desultory fashion, the practical possibilities of washing or wiping of vegetables to remove residues is as yet uncommon, except in the case of the canning business. With certain types of produce such as tomatoes, peppers, beans, asparagus, and cucurbits, removal might be accomplished satisfactorily by mechanical or chemicals means, as with fruit, without adversely affecting the appearance of the product, provided such means came within the bounds of economic probabilities. With leafy vegetables as cabbage, cauliflower, broccoli, lettuce, and celery, the possible effectiveness or practical nature of such an operation seems less likely, although it is with this type of vegetable that the need for residue removal seems most pressing. In the cases of cabbage and cauliflower close trimming the heads has been found to be a practical method of eliminating the risks attached to arsenical residues, since by this method all the older leaves are discarded, and thereby much of the residue lodging on the plant is removed. However it should be mentioned that the necessary reduction in the size and weight of the head by this method has been a cause for considerable dissatisfaction and evasion among growers that are accustomed to a more bulky pack.

Within recent years efforts have been made to develop insecticides that might in some measure compete successfully with arsenicals and at the same time do away with the residue problem. Attention has been drawn to the possibilities of the fluorine compounds, such as calcium and barium fluosilicates and cryolite. These compounds were considered relatively safe to use as insecticides from the standpoint of human health when compared with arsenicals. However, whatever be the merits of the case there appears to be sufficient evidence at hand to establish the deleterious character of certain fluorine compounds, thereby bringing about suspicion on all such compounds in their relation to human health. The result to date has been to place fluorine residues in much the same position as arsenical residues with respect to vegetables.

There are at the present time two insecticides on the market which have given promise of alleviating in a great measure the present unsatisfactory situation with regard to arsenical residues, namely, pyrethrum and derris. Both are older insecticides than the ones at present in use, but for one reason or another both have been relatively restricted in development and production.

Pyrethrum has been used on vegetables in North America as early as 1896, when it was recommended for use against celery insects. Peculiarly enough it was pyrethrum dusts which solved the arsenical residue troubles of the Florida celery growers nearly thirty years later. From 1917 to the present day there has been a notable increase in the importation, manufacture, and use of pyrethrum as an insecticide. In the vegetable industry pyrethrum has been found to be a valuable specific for certain hemipterous insects that formerly have been considered difficult to kill, such as bean leafhopper, cranberry leafhopper, squash bug, and plant bugs (*Lygus* sp.). The product has also been used with marked effectiveness against adults of certain beetles. Pyrethrum sprays and dusts have been recommended as satisfactory substitutes for the use of arsenicals during the later period of plant growth to offset the risks involved with residues at harvest time. It seems that pyrethrum is toxic to the immature stages of many insects. The chief drawbacks to its more general use at present are lack of stability with respect to the chemical composition of the active principles when exposed to outdoor and storage conditions and their relatively high cost. No doubt future development will serve to correct both these handicaps.

Unlike pyrethrum, derris has only recently become generally known in North America as an insecticide of considerable promise. In England it has become sufficiently well known to warrant its recommendation for cabbage worms. As early as 1924 Kelsall and his coworkers in

Nova Scotia had demonstrated that derris was toxic to a number of insects including larvae of the Colorado potato beetle, the imported cabbage worm and potato aphids. Following the results of further investigations by the Federal Bureau of Chemistry and Soils, and the Division of Food and Drugs Administration of the United States Department of Agriculture into the matter of arsenical substitutes, interest in the importation and manufacture of derris products has enormously increased. During the past season considerable experimentation has been carried on in many vegetable growing areas of the United States with a view to testing the possibilities of the new organic insecticides under outdoor conditions, and especially as a substitute for arsenicals. Fortunately importers of derris had sufficient material on hand to warrant a reasonably priced article should there be a demand for such products. As has already been mentioned, it became very evident in the fall of 1932 with the increasing difficulties connected with arsenical residue on certain types of vegetables that something would have to be done by growers to prevent a recurrence of such conditions during the forthcoming season. Where such was the problem chief reliance has been placed in the use of derris and derris-pyrethrum dusts, and these materials have for the present served to improve the situation in many districts. Perhaps an example of what was involved in such a situation is to be found in the case of the cauliflower industry on Long Island, a business representing an investment of half a million dollars. In the fall of 1932 the marketing of the crop was interrupted in the middle of harvest owing to the prevalence of excessive amounts of arsenical residue in the fields. Within a week, thanks to the efforts of Federal, State, and Experiment Station workers, a way was found of surmounting the difficulties, and produce was permitted to be marketed if trimmed to within three leaves of the curd. This method was adopted purely as an emergency measure, and gave little if any satisfaction to buyer or seller. However the crop was harvested. With the commencement of the 1933 growing season both derris and pyrethrum were used in field experiments in the hope that sufficient local information might be obtained regarding their merits to warrant their recommendation for worm control on the main crop in the fall. Both materials produced favorable results on early cauliflower and cabbage crops, with the result that dusts of .5 to 1 per cent rotenone strength, or of a combination of active principles comparable thereto, have been used almost entirely for the protection of 4000 acres of late cauliflower against worms. The auction block of the Long Island Cauliflower Association, in contrast to the unsatisfactory conditions existing during the previous year, has progressed throughout the season without

a hitch, disposing of about 275,000 crates of cauliflower. It is estimated that about 150 tons of ready prepared derris dusts were sold by dealers on Long Island as substitutes for calcium and lead arsenates. The price of these dusts averaged 12 to 14 cents per pound, as compared with 7 cents for arsenicals. The vast majority of dealers and growers are satisfied with the new deal, and do not expect to revert again to the use of arsenicals for worm control on cauliflower. Similarly derris dusts have been used successfully as substitutes for magnesium arsenate for the control of the Mexican bean beetle on snap and lima beans during the period of pod formation. The chief criticism of derris dusts, if such it may be called, was that these dusts appeared to function largely as contact poisons, and as such had their limitations. The presence of the dust on the foliage tended to deter feeding rather than encourage it, and because of this the effectiveness of applications was sometimes thought to have been impaired.

With respect to future policies and recommendations, it seems to me most evident that so long as arsenicals are employed to control certain vegetable insects there will always remain the risks attached to its use in relation to human health. The adverse publicity attached to incidents resulting from ignorance or careless handling serve to undermine that confidence so necessary to establish profitable business relations between producer, buyer, and consumer. Undoubtedly it will be found that in many vegetable growing districts there may be no need to restrict the use of arsenicals, or that at most applications during the later period of plant growth may be restricted to the use of poisons of a nonresidual nature. However well meaning such recommendations may be it should not be forgotten that they will be subject to a wide variation in interpretation by those that use them, with the resultant risks attached thereto. Fortunately there are at present on the market at reasonable cost organic insecticides, such as derris and pyrethrum, that have shown marked promise in controlling many common vegetable insects. To me, it seems the better policy under the circumstances to push the development and use of such materials gradually but surely with a view to the ultimate discarding of arsenicals as poisons for vegetable insects, rather than to compromise the issue by relying in part on the continued though restricted use of arsenicals.

LATEST DEVELOPMENTS IN WASHING APPLES[1]

By R. H. ROBINSON, *Chemist, Oregon Agricultural Experiment Station*

The establishment of a definite tolerance for lead on fruit and vegetables, in addition to the arsenic tolerance that has prevailed during the past few years, has necessitated intensive investigations in order that it might be possible to recommend to the fruit industry satisfactory methods for cleaning apples and pears. Chemical analyses of many lots of washed apples showed that while the arsenic was removed well below the .01 grain tolerance, lead remained on the fruit in comparatively large amounts. In some cases very little of the lead had been removed by the washing process. Thus the industry was faced with a new problem of lead residue. The immediate need was to learn what complications prevented the removal of the lead by the various solvents and by what means they could be overcome.

Preliminary laboratory studies indicated that most of the commonly used solvents removed effectively both lead and arsenic from sprayed apples when no complications prevented contact between the solvent and the arsenical particles. When, however, the lead arsenate particle is protected by a film of wax, oil, or dust deposits, free contact between the solvent and the lead arsenate is prevented and the solvent action is slowed up. Under these conditions the arsenic, which is changed to a very soluble form, readily passes into solution. The lead, however, tends to reprecipitate as an insoluble salt, and continues to adhere to the fruit.

FACTORS THAT COMPLICATE THE REMOVAL OF SPRAY RESIDUE.—Plans for the successful cleaning of fruit must begin during the growing season, when the orchardist should avoid excessive spraying and follow good orchard practices. Apples harvested at the proper time and washed immediately after picking can be cleaned well below the proposed .014 lead tolerance, unless prevented by certain complicating factors that may be unavoidable. Efforts should be made to prevent development of the following complications:

1. Heavy wax deposits on the surface of the apple makes effective cleaning difficult. Most varieties of apples develop a film of natural wax on the surface of the fruit by harvest time. The amount of wax that forms, however, depends upon the variety and conditions under which the fruit is grown. Adverse or abnormal conditions such as insufficient water, low fertility of the soil, insect infestation, and the physiological stimulation of wax excretion by the application of the various sprays,

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especially oil sprays, may influence materially the amount of wax that accumulates on the surface of the apple.

2. Oil sprays used in excess or applied too near harvest complicate spray residue removal. This is especially true when oils are used that contain heavy fractions that do not volatilize before harvest. Commercial emulsions of poor quality, improperly made home-made emulsions, and over-spraying, may deposit excessive amounts of oil that may prevent effective cleaning.

3. Foreign materials, such as dust and debris washed down from the limbs of the tree, insoluble spray materials, such as sulfur sprays that are often used in combination with lead arsenate, and peculiar calyx end formations or roughness of the fruit, may all contribute to the difficulty of the washing process.

WASHING EQUIPMENT.—Manufacturers of commercial washing machines have made improvements each year and excellent equipment is now available to the industry. Faced with the more difficult problem of removing lead residue, most of the different types of commercial machines and various experimental modifications of some of these were used in washing tests. The different types of machines, used together with the modified forms, may be described as follows:

Overhead flood, fan sprays, impeller flooding, overhead flood with underneath Tampico brushes, overhead flood with underneath Tampico brushes with brushes oscillating, overhead flood with underneath velour covered rollers, overhead flood with underneath velour covered rollers with rollers oscillating, overhead flood with underneath rubber brushes, overhead flood with underneath rubber brushes oscillating, a tandem set-up of two machines containing alkali in the first unit and acid in the second unit, a tandem set-up where a pre-dipping tank was attached to a commercial washer, and flotation or paddle type machines.

The most important requirement perhaps for all machines is that the washing solvents flood the fruit continuously during the cleaning process. For fruit difficult to clean, rotating brushes increase the cleaning action of the solvent materially. Both Tampico bristle brushes and rubber brushes have given excellent results. The rubber brushes with projecting fingers of varying lengths may prove especially effective where excessive deposits of spray and dust accumulate in the stem end of the apple.

WASHING SOLVENTS.—While many solvents have been tested in the laboratory for their selective action on lead, part of which have been tried out in washing machine experiments, two only stand out worthy of general recommendation. These are hydrochloric acid and sodium silicate. When these solvents are fortified by such materials as kerosene or light oil, (emulsified or straight, depending upon the type of machine

used) certain neutral salts, such as sodium chloride, and wetting or degumming agents, such as the commercial Vatsol, a more effective cleaning of apples has been obtained. It is necessary, however, to use these combination solvents in the proper manner and in an adaptable machine.

Hydrochloric acid compared with sodium silicate is much more rapid in its solvent action, and is effective for washing easily cleaned fruit at lower temperatures (50° F. to 80° F.). At the higher temperatures (100° F. and above), it may cause fruit burn more readily than does the silicate. Sodium silicate, on the other hand, functions best at higher temperatures (100° F. or above). Besides its chemical solvent action for lead arsenate residue, it also has a mechanical detergent effect whereby part of the waxy film on the apple is removed. Undoubtedly part of the lead arsenate is removed mechanically along with the wax. For best results, sufficient soap should be added to the sodium silicate solution in order to produce a definite but not excessive foaming action. When too much soap has been added inadvertently, it may be controlled by the addition of small amounts of odorless kerosene. Experimental tests by the Washington Experiment Station workers indicate that best results are obtained with sodium silicate when machines are constructed with under brushes in the tank, where foam can be maintained over the brushes, allowing the fruit to enter the mass of foam and become wet before it passes into the actual washing part of the machine.

Limited tests show that excellent results may be obtained with sodium silicate when highest temperatures are maintained, combined with the shortest time of exposure possible without causing injury or cracking around the calyx of the fruit. Some packing houses adopted the procedure of first putting through a test sample, chosen from a lot of apples, with the temperature maintained at a point where injury was just visible. Then the temperature was lowered 5° F. below this point and the whole lot of fruit washed under these conditions.

Fruit Cleaning Operations.—It is difficult to make definite statements regarding conditions under which fruit can be cleaned and to draw conclusions from either experimental or packing house results, since so many factors may contribute to the success or failure to obtain satisfactory cleaning. By effective cleaning, reference here is made to the removal of the lead residue below the proposed .014 grain tolerance. At the same time, arsenic would automatically be lowered below the .01 grain tolerance. This discussion also assumes utilization of improved washing equipment since a large percentage of the older washers will not clean lead from apples below the .014 tolerance.

As a convenient means of reference, apples may be classified as easily cleaned, difficult to clean, and very difficult to clean.

Apples that are classified as easily cleaned carry only a medium lead residue load (around .12 grain per pound) have not developed very much wax at the time of washing, and have not received applications of oil spray. This class of fruit may be washed effectively in either hydrochloric acid or sodium silicate solution. If the spray residue load is not too heavy, hydrochloric acid may be used without artificial heat. Sodium silicate, on the other hand, should be heated to around 90° F. to insure proper lead removal. Usually hydrochloric acid is the preferable solvent to use for fruit comparatively easily cleaned, since sodium silicate functions best with waxy fruit. Most available machines will handle this class of fruit successfully.

When apples become difficult to clean, owing to a fairly heavy lead arsenate load, and complicated with appreciable amounts of wax or oil, either fish or petroleum oil, more rigid control of the washing procedure is necessary. When acid is used as a solvent it may be increased to 1.8 per cent and the solution heated to around 100° F. The machine must be slowed down to a point where effective cleaning is obtained. When sodium silicate is employed as the solvent, it may be used at the rate of about 80 pounds to 100 gallons of water, the solution heated to about 110° F. or a little better, and the speed of the machine regulated to produce satisfactory results. If the apples have been sprayed with the fish oil-lead combination, or an appreciable amount of wax has formed, sodium silicate is the more effective solvent. Apparently under these conditions there is a mechanical removal of the wax and residue by the detergent and emulsifying action of the silicate. When the temperature of the washing solution is above 100° F., burning or other injury may easily occur. Some apples, although of the same variety, may not be as waxy as others in the same lot and will therefore be more easily injured. It is very important, therefore, no matter which solvent is employed, to regulate carefully the temperature, concentration of the solvent, and the time the fruit is in the solvent in order to avoid injury to the fruit.

For the worst lots of fruit and the class most difficult to clean, a rather severe washing treatment is necessary. An additional cleaning action may be secured by fortifying the solvent with either kerosene or light petroleum oil (either emulsified with kaolin or used straight, depending upon the machine being operated), or by the use of ordinary salt. These supplementary materials may function best in the hydrochloric acid wash, although under some conditions they are beneficial when used with sodium silicate. Furthermore, this class of fruit must be washed in machines equipped with rotating brushes in order to clean effectively.

The temperature of the acid may be maintained at 110° F. or when sodium silicate is used it may be increased to 120° F. Under these high temperature conditions it is important that the temperature, concentration of the solvent, and time the fruit is in the solvent are very carefully regulated to insure cleaning and yet avoid injury to the apples.

Experimental washing tests confirmed by packing house observations show that there are limitations to the effectiveness of many of the commercial washing machines. With some of the older types it has been difficult to remove the lead below the .02 tolerance. A tandem set-up of two different machines or a pre-dipping tank connected with the commercial machine has proved highly successful as a substitute for the ineffective washers. Sodium silicate is recommended for use in the first unit, and hydrochloric acid in the second. For apples most difficult to clean, 75 pounds of sodium silicate may be used in the first unit, maintained at 110° F., and the time in the solvent regulated to suit the fruit at hand. In the second unit, 1.5 per cent hydrochloric acid may be maintained at around 100° F. for 30 seconds. As the apples pass through this tandem set-up, there is a combined chemical and detergent action by the sodium silicate and soap, whereby part of the residue and waxy coating on the fruit is removed. Then the fruit passes into the acid unit where effective cleaning is completed. The washing treatment that may be given in a double machine set-up is limited only by what the fruit will endure without causing injury. The temperatures and time in the solvents should be carefully regulated depending upon the waxiness of the fruit to be cleaned. Whenever possible the acid in the second unit should be used without artificial heat.

During the past season many packing houses have used a modification of the double machine set-up whereby a pre-dipping tank was connected to a washing machine. The apples were dumped into this tank, forced along and onto a conveyor that led into the washing machine. A spray of fresh water was provided in order to rinse the dipping-tank solvent from the apples as they passed into the machine. A dipping wheel that submerged the apples slightly as it moved the fruit forward in the tank proved beneficial.

Various materials were added to the water in the pre-dipping tank, depending upon the condition of the apples to be cleaned. These were as follows:

1. Hot water only. 2. Kerosene or light (55 viscosity or less) petroleum oil emulsified with kaolin (1 gallon to 100 gallons of water, or to 100 gallons of 1 per cent hydrochloric acid). 3. Sodium silicate (25 pounds to 75 pounds in 100 gallons of water). The temperature of the

solution in the pre-dipping tank was maintained at 80 to 100° F., depending upon the fruit to be washed. Higher temperatures were necessary for the worst apples when sodium silicate and soap were used. Hydrochloric acid was ordinarily used in the washing machine unit of this set-up. By varying the length of time in the pre-dip before passing into the washing machine unit, and controlling time in the solvents and temperature and concentration of the acid solution, excellent results were obtained.

WETTING OR DEGUMMING AGENTS.—Following the suggestions of McLean and Webber, wetting or degumming agents, such as the commercial Vatsol have been tried out. When these compounds were used with hydrochloric acid in the flotation or paddle type washer, effective cleaning was obtained.

The degumming agents also gave excellent results when used in the commercial fruit washer. However, since agitation occurs in most commercial machines, it is necessary to use an anti-foam compound to overcome excessive foaming. At this writing, no anti-foam compound has been tested that has not caused injury to the fruit.

THE REMOVAL OF FLUORINE COMPOUNDS FROM APPLES.—Since the use of fluorine sprays for codling moth control in Oregon has been very limited, no investigations for the removal of these compounds have been undertaken. The investigations carried on by the U. S. Bureaus of Plant Industry and Chemistry and Soils, indicate that when the fluorine compounds are used in only two or three cover sprays, either hydrochloric acid or sodium silicate cleaned the fruit effectively below the prevailing .01 grain tolerance. When used in combination with either mineral oil or fish oil in all cover sprays, it was not removed satisfactorily by any cleaning treatment. Further information is necessary before definite recommendations can be made regarding these compounds.

CONCLUSIONS.—It may be concluded from the past season's washing experiences that before the industry can meet the proposed .014 tolerance for lead, careful spraying operations must be carried on by the orchardist to avoid over-spraying and to use a schedule that promises least difficulty in residue removal. Then, in order to remove lead and arsenic effectively improved washing equipment must be available for the cleaning process.

INFLUENCE OF SPRAY SCHEDULE AND OTHER FACTORS ON SPRAY RESIDUE REMOVAL[1]

By HARRY C. McLEAN and ALBERT L. WEBER, *New Jersey Agricultural Experiment Station, New Brunswick, N. J.*

In 1931 several New Jersey fruit growers adopted the use of summer oil in conjunction with lead arsenate as a spray to combat codling moth. It was found at harvest that the dilute solutions of hydrochloric acid previously used with success in removing excessive spray residues failed to reduce arsenical residues sufficiently in the presence of oil to meet the existing arsenic tolerance. (1)

Heated alkaline washes were being used at that time with marked success for removing arsenical residues in the Pacific Northwest. The application of this method required specialized equipment as well as careful temperature control and appeared impracticable for New Jersey growers, inasmuch as New Jersey fruit growers were unorganized, lacking the large packing and marketing organizations which permitted large scale cleaning operations. Moreover, the average New Jersey grower washed only from 500 to 8,000 bushels of fruit per year, except for a few instances in which as many as 50,000 bushels of fruit were handled annually.

Investigations were therefore undertaken at the New Jersey Agricultural Experiment Station in an endeavor to find a suitable comparatively inexpensive material for admixture with hydrochloric acid solution capable of economically removing, at ordinary temperatures, arsenical residues from oil-lead arsenate sprayed fruit.

A wide range of solvents was tested with the result that the "New Jersey Method" of spray residue removal was developed which is efficient in removing arsenical as well as lead residues from fruit. (1) (2) The method consists of the use of a mixture of a textile wetting or degumming agent and dilute hydrochloric acid. The relative proportions of the components of the cleaning mixture are varied depending on the conditions present. For apples which are extremely difficult to clean, the washing mixture recommended contains 5 to 5½ gallons of 20° Baumé hydrochloric acid, 8 pounds of the wetting or degumming agent Vatsol, and 100 gallons of water. This cleaning process not only dispenses with the use of heated solutions, but also is readily adapted to various types of cleaning equipment.

[1]Journal Series paper of the New Jersey Agricultural Experiment Station, department of spray residue investigations.

In the flood or spray type fruit washer, the constant violent agitation of the cleaning solution tends to cause excessive foaming of the acid-wetting agent solution. This can be readily controlled by the addition of a defoaming agent. A 50 per cent solution of degras in purified naphtha has been found (3) most effective in this respect. The addition of only 1½ pints of such a mixture per 100 gallons of wash solution will avoid all difficulty experienced from foaming.

Two years' observation of stored apples which had been washed by the "New Jersey Method," showed that the treatment did not impair the keeping quality of the fruit. No burning was ever noted where proper rinsing was practiced.

SPRAY SCHEDULE AND SPRAY RESIDUE REMOVAL. — Attention has been directed, during the past two years, to the effect of different spray schedules on removal of spray residues from the harvested fruit. The results of this study are given in Table 1. The cover sprays designated as *27*, *37* day, etc., refer to the number of days after the petal-fall spray application.

In New Jersey, 7 and 17 day applications are recommended for apples, with subsequent applications at 10 day intervals where the previous crop has shown 50 per cent or more codling moth injury on the harvested crop. Sulfur is used in the spray mixture up to and including the 17 day application, and oil and a non-sulfur fungicide or no fungicide in subsequent sprays.

The data presented in the following tables represent the average of at least eight separate analyses. The wetting and degumming agent used in these tests is one sold under the trade name of "Vatsol."

It was found that varieties of apples maturing prior to Wealthy may receive four applications of a mixture consisting of 3 quarts summer oil, 2 pounds lead arsenate and 100 gallons of water and be successfully washed in dilute hydrochloric acid *alone*. In general, the early varieties of apples are harvested prematurely in New Jersey and do not become as waxy as Wealthy and later maturing varieties. If summer oil in a concentration of 3 quarts per 100 gallons is applied to late summer and winter varieties of apples as they near maturity, an excessive amount of wax apparently develops.

The number of 3 quart applications of summer oil applied to the apples, represented by Lots 10, 11, 12 and 13, in Table 1 are probably in excess of that normally used in New Jersey or other sections of the east.

In view of reports, injury to the trees might readily result from so many heavy oil applications of this sort made year after year. Lots

TABLE 1. RELATION OF SPRAY SCHEDULE AND VARIETY TO SPRAY RESIDUE REMOVAL

Lot No.	Variety and summer oil (SO), Lead arsenate (LA) spray schedule‡	Date of last 3 quart summer oil application	Date of last lead arsenate application	Date fruit was harvested	Residue on fruit before washing		Washing treatment			
					As_2O_3	Pb	1.75% As_2O_3	HCL† Pb	1.75% As_2O_3	HCl+1% Vatsol† Pb
					Grains per pound of fruit					
	Stayman									
1	LA 3 lb.; Fluxit ½ lb.; beginning with 17 da. after petal fall spray, 9 cover sprays at 10 da. intervals	0	9/4	10/20	.117	.271	.001	.006		
	Stayman									
2	SO 3 qt.; LA 2 lbs.; Fluxit ½ lb.; on 27, 37 and 47 day covers, followed by 8 covers of oil and nicotine sulfate	6/23	6/23	10/20	.009	.023	.001	.004		
	Starr									
3	SO 3 qt.; LA 2 lb.; Fluxit 1 lb.; on 27, 37, 47 and 57 day covers	7/3	7/3	7/9	.034	.098	.001	.004		
	Winesap									
4	SO 3 qt.; LA 2 lb.; Fluxit 1 lb.; on 37 and 47 day covers. SO 1 qt.; LA 3 lb.; 1 lb. Fluxit on 27, 67, 87 and 107 day covers	6/23	8/25	10/3	.027	.086	.004	.014		
	Stayman									
5	SO 3 qt.; LA 2 lb.; Fluxit 1 lb. on 27, 37, 47 and 77 day covers. SO 1 qt.; LA 3 lb.; Fluxit 1 lb. on 67, 87 and 97 day covers	7/24	8/15	10/6	.015	.042	.002	.007		
	Wealthy									
6	SO 3 qt.; LA 2 lb.; Fluxit 1 lb. on 27, 37, 47 and 77 day covers. SO 1 qt.; LA 3 lb.; Fluxit on 67, 87 and 97 day covers	7/24	8/15	8/22	.016	.055	.006	.022	.003	.009
	Stayman									
7	SO 3 qt.; LA 2 lb.; Fluxit ½ lb.; on 27, 37, 47, 67 and 77 day covers. SO 1 qt.; LA 3 lb.; Fluxit ½ lb.; on 57, 87, 107 and 117 day covers	7/24	9/4	10/20	.074	.187	.009	.040	.003	.011
	Starr									
8	SO 3 qt.; LA 2 lb.; Fluxit 1 lb. on 27, 37, 47, 57, 67 and 77 day covers	7/24	7/24	7/28	.042	.128	.013	.052	.003	.011

	Grimes									
9	SO 3 qt.; LA 3 lbs.; Fluxit 1 lb. on 37 and 97 day covers. LA 4 lb. on 27, 47, 57, 67, 77, 87 and 107 day covers	8/15	8/25	9/9	.062	.198	.009	.028	.003	.012
	Wealthy									
10	SO 3 qt.; LA 2 lb.; Fluxit 1 lb. on 27, 37, 47, 57 and 67 day covers. LA 3 lb.; Fluxit 1 lb. on 77 day cover	7/13	7/24	8/8	.058	.188	.010	.038	.005	.018
	Wealthy									
11	SO 3 qt.; LA 2 lb.; Fluxit 1 lb. on 27, 37, 47, 57, 67 and 77 day covers. SO 1 qt.; LA 3 lb.; Fluxit 1 lb. on 72 and 97 day covers	7/24	8/15	8/18	.043	.155	.015	.065	.006	.019
	Grimes									
12	SO 3 qt.; LA 2 lb.; Fluxit 1 lb. on 27, 37, 47, 57, 67 and 77 day covers. SO 1 qt.; LA 3 lb.; Fluxit 1 lb. on 72, 97 and 117 day covers	7/24	9/4	9/12	.061	.219	.020	.057	.006	.019
	York Imperial									
13	Same schedule as Lot No. 12	7/24	9/4	10/20	.079	.233	.012 .006*	.076 .031*	.007 .001*	.033 .009*

*Washed at a temperature of 100°F for 90 sec.
†Washed at a temperature of 60°–70°F for 90 sec. in flotation paddle washer.
‡Quantities used per 100 gallons of spray mixture.

10 to 13 were taken from orchards where codling moth infestation in the past was very severe. An effort was made to reduce codling moth infestation in one or two years to a degree which would permit the adoption of a less intensive spray program in subsequent years.

With the aid of "Vatsol" the arsenic and lead residues were reduced sufficiently at ordinary temperature (60–70° F.) on Lots 10, 11 and 12 to meet the Federal spray residue tolerance.

It should be noted that although York Imperial apples Lot 13 received the same spray schedule as the Grimes Lot 12, they did not wash equally well. This was no doubt due to the excessive wax formation stimulated by the numerous oil sprays (4) and delayed harvesting. The first harvested apples of Lot 13 which were washed as picked did not require heated wash solutions in order to remove residues sufficiently.

The apples represented by Lots 1 to 9 inclusive could be effectively washed at atmospheric temperatures in any type of commercial machine, provided the proper period of contact between the fruit and the wash solution was maintained. For Lots 6, 7, 8 and 9, a wetting agent in conjunction with 1.75 per cent hydrochloric acid was essential in order to satisfactorily remove the residues. On the other hand, the spray program followed on Lots 11 and 12 (Table 2) made it necessary to use a wetting agent, to heat the solution to 100° F., and to increase the period of contact of the fruit with the wash solution where commercial washers were employed. This reduction in speed of the washer would seriously curtail the capacity of the washer. It will be noted that Lots 11 and 12 were satisfactorily cleaned in a flotation washer without heat.

EFFICIENCY OF THE PRE-DIP TANK IN REMOVING SPRAY RESIDUES.—The York Imperial apples Lot 13, were washed by the grower employing a flotation paddle washer with the rinse tank eliminated as a pre-dip tank. The fruit was then passed through a commercial washer for final rinsing and drying. The apples were exposed for 90 seconds to a solution composed of 8 pounds of Vatsol and 5½ gallons of commercial 20° Baumé hydrochloric acid per 100 gallons of water. The temperature of the washing solution was maintained at 80–90° F. In some cases greater capacity and efficiency has been obtained by using the acid-wetting agent mixture in the commercial washer as well as the pre-dip tank.

It has been the experience of New Jersey growers whose apples are difficult to wash and who have commercial equipment that it is necessary to either utilize the pre-dip tank or heat the wash solution, the former being the most economical.

Table 3 shows results obtained where a pre-dip tank was used as an adjunct to a Bean commercial washer.

TABLE 2. REMOVAL OF ARSENIC AND LEAD BY THE AID OF A WETTING OR DEGUMMING AGENT IN DIFFERENT TYPES OF WASHERS

Washing treatment	Type of washer used: (Flood)				(Spray)				(Flotation)			
	Time of contact with washing solution: 24 sec.		48 sec.		27 sec.		54 sec.		90 sec.		150 sec.	
	As_2O_3[1]	Pb[1]	As_2O_3	Pb	As_2O_3	Pb	As_2O_3	Pb	As_2O_3	Pb	As_2O_3	Pb
Grimes Lot No. 12												
Check, unwashed	.061	.219	.061	.219	.061	.219	.061	.219	.061	.219	.061	.219
1.75% HCl at 60°–70°F	.029	.060	.014	.036	.012	.053	.012	.042	.020	.057	.015	.045
1.75% HCl at 100°F	.027	.055	.006	.020	.009	.044	.007	.030				
1.75% HCl+1% Vatsol at 60°–70°F	.020	.038	.016	.031	.012	.058	.007	.035	.006	.019	.003	.013
1.75% HCl+1% Vatsol at 100°F	.005	.011	.004	.010	.007	.025	.004	.017				
Wealthy Lot No. 11												
Check, unwashed	.043	.155	.043	.155			.043	.155	.043	.155	.043	.155
1.75% HCl at 60°–70°F	.017	.045	.012	.037			.021	.061	.015	.065	.012	.038
1.75% HCl at 100°F												
1.75% HCl+1% Vatsol at 60°–70°F	.017	.051	.009	.029			.016	.056	.006	.019	.004	.012
1.75% HCl+1% Vatsol at 100°F	—	—	—	—	—	—	—	—	—	—	—	—
York Imperial Lot No. 13												
Check, unwashed	—	—	—	—	—	—	.079	.233	.079	.233	.079	.233
1.75% HCl at 60°–70°F	—	—	—	—	—	—	.016	.092	.012	.076	.019	.095
1.75% HCl at 100°F	—	—	—	—	—	—	.013	.065	.006	.031		
1.75% HCl+1% Vatsol at 60°–70°F	—	—	—	—	—	—	.014	.074	.007	.033	.009	.031
1.75% HCl + 1% Vatsol at 100°F	—	—	—	—	—	—	.008	.034	.001	.009		

[1]All results are given in grains per lb. of fruit.

TABLE 3. EFFICIENCY OF THE PRE-DIP TANK IN REMOVING SPRAY RESIDUES

Washing treatment	Pre-dip tank for 90 seconds then through bean washer for 30 seconds*	
	As_2O_3	Lead
	Grains per lb. of fruit	
None	.04	.119
1.75% HCl	.010	.043
1.75% HCl+1% Vatsol	.004	.012

*1.75% HCl and 8 lbs. Vatsol per 100 gallons in pre-dip and washer.

WASHING CIDER APPLES.—The spray residue problem presents no particular difficulties in the manufacture of cider itself. Numerous samples of cider collected from plants in New Jersey have been analyzed during the past. In no instance has there been more than a trace of arsenic or lead found, except where cider was made from partially fermented apples. Since practically all spray residues remain in the pomace, a by-product of cider manufacture, it is the marketing of the pomace for the manufacture of pectin, as feed, etc., which is seriously affected. Moreover, the residues are greatly concentrated in the pomace, with the result that cider manufacturers are faced with the necessity of washing cider apples intended for this purpose.

Tests have shown that in kiln dry pomace the residues are increased approximately 10 times the original residue concentration of the fruit. It is apparent that cider apples can contain no more than .0019 grain of lead per pound of fruit in order to meet the lead tolerance and permit marketing of the pomace in compliance with Federal legislation. Likewise in moist pomace, residues are concentrated 5 to 6 times, with the result that the original fruit must not contain over .003 or .004 grain of lead per pound.

As shown in Table 4, washing tests were conducted on 2 lots of cider apples to determine whether the residue content of the fruit could be reduced sufficiently to eliminate over-concentration of spray residues in the pomace.

In Lot 1, the original fruit contained .013 grain of lead per pound, the resulting moist pomace, analyzing .062 grain per pound, and kiln dry .134 grain per pound. Although the apples were well below the .019 grain lead tolerance in this instance, the pomace exceeded the minimum tolerance as a result of concentration of residues. Similarly in Lot 2 the original residue content of .120 grain lead on the fruit was increased to 1.176 grains for the kiln dried pomace and .624 grain for the moist.

Washing tests conducted with hydrochloric acid alone, on Lot 1 which received no oil sprays, reduced residues sufficiently to produce a moist pomace within the minimum tolerance. On the other hand, it was neces-

sary to add Vatsol to the acid in order to effect a similar reduction in the kiln dried pomace.

TABLE 4. REMOVAL OF ARSENIC AND LEAD RESIDUES FROM CIDER APPLES

Washing treatment of apples	Apples		Moist pomace		Kiln dried pomace	
	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2
	Grains of lead per pound					
Unwashed	.013	.120	.062	.624	.134	1.176
1.75% HCl at 70° F., 1½ min	.003	.076	.014	.374	.031	.860
1.75% HCl, 1% Vatsol at 70° F., 1½ min	.001	.011	.004	.058	.010	.122
2% HCl at 190° F., ½ min	.003	.013	.016	.062	.034	.128
2% HCl, 1% Vatsol at 190° F., ½ min	.001	.001	.004	.005	.008	.009

It was impossible to remove residues efficiently from Lot 2 which received several oil sprays even by the addition of Vatsol at a temperature of 70° F. Raising the temperature of the solution to 190° F. (2 per cent Acid for ½ minute) proved equally unsatisfactory. However, the addition of 1 per cent Vatsol to this solution reduced residues to .001 grain of lead per pound, insuring a pomace below the Federal tolerance.

Although high temperatures produced surface burning, neither the pectin content or feeding value of the pomace were deleteriously affected.

EFFECT OF NaCl ON THE EFFICIENCY OF WASH SOLUTIONS.—In view of Robinson's (5) recent findings to the effect that the addition of salt to hydrochloric acid increased the solubility of lead arsenate, further experiments were undertaken to determine whether salt would increase the washing efficiency to such an extent that it would be unnecessary to employ heated solutions of Vatsol and acid. The apples selected for the test were from Lot 13. As shown in Table 1, heat was necessary to reduce the residues effectively. The various washing tests were made in a home-made flotation washer, allowing a 90 second period of contact of

TABLE 5. EFFECT OF SODIUM CHLORIDE ON THE EFFICIENCY OF WASH SOLUTIONS

Cleaning treatment	As_2O_3	Lead
	Grains per lb. of fruit	
None	.085	.278
1% HCl	.051	.246
1% HCl, 1% salt	.033	.154
1% HCl, 1% Vatsol	042	.168
1% HCl, 1% salt, 1% Vatsol	.013	.062
1% HCl, 10% salt	.034	.147
1% HCl, 10% salt, 1% Vatsol	.011	.056
1.8% HCl	.022	.083
1.8% HCl, 1% Vatsol	.009	.044
1.8% HCl, 1% salt	.033	.121
1.8% HCl, 1% salt, 1% Vatsol	.009	.042
1.8% HCl, 10% salt	.029	.118
1.8% HCl, 10% salt, 1% Vatsol	.009	.041

the fruit with the washing solution. The temperature of solutions were maintained at 70° F.

A comparison of the efficiency of the different treatments may be obtained from Table 5. The addition of NaCl to the 1 per cent hydrochloric acid or the 1 per cent acid-Vatsol solutions does increase their washing efficiency somewhat, but when the NaCl is added to the 1.8 per cent hydrochloric acid combination, no significant effect is shown. In no instance was the arsenical or lead residues reduced to or below the Federal tolerance.

RELATION OF SPREADERS TO ARSENICAL RESIDUE REMOVAL.—Casein spreaders used in conjunction with oil-lead arsenate sprays have been found to greatly increase the difficulty of removing residues from the harvested fruit.

The average results obtained with washing tests on three varieties of winter apples which had received identical oil-lead arsenate spray sched-

TABLE 6. RELATION OF SPREADERS TO ARSENICAL RESIDUE REMOVAL

Treatment	Spreader used		
	Casein No. 1	Casein No. 2	Non-Casein
	Residue in grains per lb. of fruit		
	As_2O_3	As_2O_3	As_2O_3
Not washed	.120	.095	.11
Washed with acid	.035	.025	.008
Washed with acid-wetting or degumming agent	.006	.005	.003

ules are given in Table 6. As indicated, casein No. 1 represented a commercial spreader containing casein, casein No. 2, powdered skim milk and the non-casein spreader, a product of the colloidal protein type recommended for use with oil-lead arsenate sprays. The test orchards received an equal amount of spray material per 25' x 25' tree, each application. On the basis of the above tests and the comparison of the analyses of lead and arsenic residues on over 2,000 samples of fruit, it may be stated that the difficulty of removing lead as well as arsenical residues is greatly reduced by the use of non-casein spreaders in the spray program.

THE INFLUENCE OF INSECT RESIDUES ON SPRAY RESIDUE REMOVAL.—Many of the York Imperial apples, Lot 13, receiving the spray schedule indicated in Table 1 were covered at time of harvest with "honey dew" which was exuded by a heavy infestation of aphis. It was believed that the "honey dew" residue might possibly be the cause of the difficulty experienced in washing the fruit. Washing experiments were conducted with fruit showing heavy residues of "honey dew" in comparison with fruit displaying very little or no "honey dew" residues. Contrary

to the expectations, the heavy "honey dew" residue fruit contained less spray residue and washed far more easily than fruit without such residues, as shown in Table 7.

TABLE 7. INFLUENCE OF "HONEYDEW" RESIDUES ON SPRAY RESIDUE REMOVAL

Washing treatment	Fruit* with heavy "Honeydew" residues		Fruit* without "Honeydew" residues	
	Pb.	As_2O_3	Pb.	As_2O_3
	Grains per lb. of fruit			
Check, unwashed	.125	.049	.181	.073
Washed in 1.75% HCl+1% Vatsol, 90 sec. 65°F	.037	.013	.061	.023
Washed in 1.75% HCl+1% Vatsol, 90 sec. 100°F	.014	.005	.017	.006

*York Imperials of Lot No. 13.

REMOVAL OF SPRAY RESIDUES WITH ALKALINE WASHES.—Particular difficulty was experienced in cleaning the York Imperial apples represented by Lot 13 in Table 1. Since heat had to be resorted to, it was deemed advisable to test the efficiency of alkaline washes, especially BW Silicate as reported by Overley (6). Various alkaline washes were tested alone and in combination with soap and Vatsol. The most effective alkaline treatment for reducing the lead content of the fruit was a washing mixture containing 10 per cent BW Silicate and 1 per cent Vatsol maintained at a temperature of 115° F. for 2½ minutes. Although these tests were conducted in a home-made flotation washer, the results in Table 8 indicate that the heated Vatsol-BW Silicate mixture will

TABLE 8. REMOVAL OF SPRAY RESIDUES WITH ALKALINE WASHES

Cleaning treatment	As_2O_3 grs. per lb.	Pb grs. per lb.
10% BW silicate, 2.5 min., 115°F	.006	.043
10% 40° Be. silicate of soda 1.5 min., 115°F	.028	.138
10% Na_3PO_4, 1.5 min. 110°F	.010	.092
10% BW silicate+1% liquid soap, 2.5 min., 115°F	.004	.024
10% BW silicate+½% Vatsol, 2.5 min., 115°F	.005	.025
10% BW silicate+1% Vatsol 1.5 min., 115°F	.004	.025
10% 40° Be. silicate of soda+1% Vatsol, 1.5 min., 115°F	.012	.060
10% Na_3PO_4+1% Vatsol, 1.5 min., 110°F	.006	.082
10% BW silicate+1% Vatsol, 2.5 min., 115°F	.004	.019
Check, unwashed	.088	.242

prove equally effective in all types of commercial washers provided the proper period of contact with the wash solution is maintained.

A limited number of experiments indicate that wetting agents increased the efficiency of alkaline silicates in removing fluorine residues from fruit.

RECOMMENDATIONS DESIGNED TO FACILITATE RESIDUE REMOVAL.—The results of investigations reported in this paper make it possible to

recommend to New Jersey fruit growers the following procedures in relation to spray residue removal.

When oil is not used in combination with lead arsenate in the spray schedule, in addition to a casein or colloidal protein type spreader, all varieties of apples may be sprayed up to time of harvest and the residues removed with cold hydrochloric acid.

Varieties of apples maturing before Wealthy may be sprayed with the oil-lead arsenate combination 27, 37, 47, 57 and 67 days after petal-fall, using a non-casein spreader and be satisfactorily washed in any type of fruit washer provided a wetting agent be added to the hydrochloric acid washing solution. Acid alone will successfully wash the fruit where oil and lead arsenate are applied no later than 57 days after petal-fall. A 67 day application of lead arsenate without oil and non-casein spreader may follow the 57 day spray.

Wealthy and later maturing varieties may be satisfactorily washed in hydrochloric acid alone if no oil-lead arsenate sprays, in the concentration of 3 quarts medium summer oil and 2 pounds lead arsenate per 100 gallons are applied no later than 57 days after petal-fall. Where similar oil-lead arsenate applications at 67 and 77 days after petal-fall are desirable, the addition of a special wetting agent to the hydrochloric acid wash solution will be essential. Satisfactory washing may be accomplished at atmospheric temperatures, however, it may be necessary to reduce the operating speed of commercial spray, brush or flood type washers in order that the fruit remain in contact with the wash solution, for at least 45 seconds. Pre-dipping the fruit for 1½ minutes in a vat containing the acid-wetting agent wash, before passage through the commercial washer, makes it possible to maintain the speed of the latter at its regular rate.

The use of any later sprays of oil and lead arsenate in the concentrations stated above may necessitate heating the washing solution in order to remove residues sufficiently.

Applications of lead arsenate and non-casein spreaders without oil after the 67 day spray does not affect the recommendations given above.

The special wetting agents now available may be used in the spray or flood type commercial washers provided a defoaming agent is added to prevent the excessive foaming caused by the violent agitation and pumping of the washing solution. Oil-lead arsenate sprays may be applied at 27 and 37 days after petal-fall, followed by oil-nicotine sprays, without resulting in spray residues in excess of the Federal tolerance on fall and winter varieties of apples at harvest.

LITERATURE CITED

1. McLEAN, H. C., and WEBER, A. L. 1931. Use of wetting or degumming agents in the removal of spray residues from apples. In Journal Economic Entomology V. 24, p. 1255.
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CHAIRMAN PARROTT: In planning the program, I fully expected we could complete the symposium in much shorter time than we have, but I felt because of the interest in this general subject it was not wise to limit the authors of papers to the period specified. I have been asked by several of the men present if I would summarize what has been said, but I think everyone present here is fully as competent to gather the principal points presented as I am.

There is this additional complication that our insect problems and our spray problems vary in the different regions of the country. I think this much can be said as compared with conditions last year.

We have heard from Mr. White regarding conditions of vegetables in the interstate traffic. We have definitely the restrictions laid down by the Food and Drug Administration, something we didn't have last year. We have a general picture regarding the situation of the codling moth in the different districts.

I think in general the bulk of the evidence points in the direction that of the insecticides, if a single one can be emphasized, it is that lead arsenate is going to constitute the main prop of the spray program generally, with modifications in some districts according to the importance of the problem, some consideration being given to oil and lead and oil and nicotine.

Those of you who didn't attend the Philadelphia meeting will be interested in knowing that in Virginia some consideration is going to be given to calcium arsenate, in that state, and, as pointed out by Dr. Chap-

man, in the Hudson River Valley and Champlain Valley and certain areas in the New England States, calcium arsenate would be used.

With regard to the apple maggot there has been no substitute found for arsenicals. There has been distinct improvement in the handling of insect control problems on vegetables—no question about that. As regards organic insecticides for the control of the codling moth, we have had some important beginnings, a large degree of credit being extended to Dr. Headlee and undoubtedly the indications he has had are going to stimulate other workers in other areas to carry on elaborate tests to develop or at least find out insecticidal properties of some materials that have been suggested.

Again, washing varies in importance in districts. In the Champlain Valley and the Hudson Valley our growers do not take time to wash them. In Western New York we have got to wash. We shall put on a very heavy spray program with lead arsenate and growers have seen the necessity in many localities of purchasing washing outfits and a much larger number have been placed in Western New York than the preceding year.

I think those that have acute codling moth situations are experiencing similar developments.

PRESIDENT HINDS: Allow me to make a statement. We want to thank Professor Parrott particularly for the effort he has put into the arrangement of this symposium and his conduct of the symposium. I am sure the subject has been of unusual interest, as manifested by your attention.

***Isotomurus palustris* (Müll.), a Springtail Injurious to Celery.** Collembola frequently have been found in small numbers about celery seed beds at Sanford, Fla., but in August 1931 the small plants of one particular group of beds were seriously injured on the under surfaces of the tender foliage by this insect. The springtails were so numerous that as one walked between the beds a foglike cloud arose. About one-third of the plants had died from the injury and the others were badly damaged. A lowering of the water table beneath the beds to cause the soil to dry out and a heavy application of nicotine dust gave almost immediate relief. The remaining celery soon recovered. Specimens from this infestation were identified as the aforementioned species by Dr. J. W. Folsom. He more recently gave a list in the Journal of Economic Entomology, Vol. 26, pp. 936–938, of the economically injurious species of Collembola and mentions *palustris* as injurious to the roots of sugarcane.

C. O. BARE, *Bureau of Entomology, U. S. Department of Agriculture, Sanford, Fla.*

Proceedings of the Fifth Annual Paper Reading Session of the Eastern Branch of the American Association of Economic Entomologists

Held at the Academy of Natural Sciences of Philadelphia
November 23 and 24, 1933

The meeting was called to order by Chairman Thomas J. Headlee, and welcomed to the Academy by Mr. James A. G. Rehn, who referred briefly to the founding of the Academy, to the first journal devoted to economic entomology, "The Practical Entomologist," to the aims of the Academy and its Department of Entomology.

Mr. Lee A. Strong, Chief of the Bureau of Entomology of the United States Department of Agriculture, expressed pleasure in meeting with the Eastern Branch and spoke briefly of the Bureau and of the cooperation he was receiving from various entomologists.

BUSINESS SESSION

First Business Session, Thursday, November 23, 1933, 12:15 P. M.

The Chairman appointed the following committees:

Committee on Nominations: C. H. Hadley, B. D. VanBuren and Geo. S. Langford.

Auditing Committee: B. A. Porter and W. J. Schoene.

Committee on Resolutions: W. E. Britton and Hugh Glasgow.

The following report of the Secretary-Treasurer was read and referred to the Auditing Committee:

Report of the Secretary-Treasurer

Paid membership in the Eastern Branch for 1932 amounted to only 69. For comparative purposes the paid membership for several years is indicated as follows:

	1929	1930	1931	1932
West Virginia	1	1	1	2
Virginia	5	4	8	5
District of Columbia	6	3	9	2
Maryland	5	6	9	3
Delaware	2	2	3	1
Pennsylvania	9	3	11	5
New Jersey	26	21	19	11
New York	27	28	39	25
Connecticut	10	9	15	5
Rhode Island	2	0	1	0
Massachusetts	6	5	14	8
Vermont	1	1	0	0
New Hampshire	0	0	1	1
Maine	0	1	2	1
Canadian Provinces	1	0	0	0
Total	101	84	133	69

Our 1932 meeting was held December 30, at Atlantic City, N. J., in joint session with the American Association of Economic Entomologists. Eight Eastern Branch papers were read at this session.

FINANCIAL STATEMENT

Balance on hand December 21, 1932		$176.48
Receipts		
Additional dues for 1932	$ 36.00	
Dues for 1933 to date	96.00	
" " 1934 " "	2.00	
Sale of advertising in 1932 program	130.00	
" " " " 1933 " to date	20.00	$284.00
Total Receipts		$460.48
Disbursements		
Mar. 2, 1933—C. C. Hamilton, postage for corres. re adv	$ 2.16	
" 2, 1933—E. R. Van Leeuwen, ret. of dues	2.00	
May 24, 1933—Amer. Assoc. Econ. Ent. on Acct. toward bal. owed on printing 1931 proceedings	250.00	
June 19, 1933—Western Union Telegrams from Dr. T. J. Headlee to 5 federal officials, protesting curtailment of ent. funds	10.61	
Aug. 18, 1933—B. Maher for 370 double post cards	7.40	
Oct. 5, 1933—Postage for mailing notices of meeting	12.00	
Nov. 8, 1933—Postage for mailing programs	6.71	
Nov. 8, 1933—Gov. tax on 8 checks	.16	
Total Disbursements		$291.04
Balance on hand Nov. 14, 1933—(Deposited in Trenton Trust Co.)		$169.44
Accounts Payable		
Balance still owed A.A.E.E. for printing 1931 proceedings in Journal		74.00
Printing 1933 program		68.00
Accounts Receivable		
To be collected from advertisers in 1933 program		220.00

HARRY B. WEISS,
Secretary-Treasurer

Dr. E. P. Felt, in advance of a questionnaire relating to publication matters, shortly to be submitted to members, gave facts which the members needed, in order to answer the questions intelligently.

Dr. C. C. Hamilton reported for the Program Finance Committee on the sale of advertising for the 1933 program.

Mr. J. W. Balock, of Moorestown, N. J., was elected an affiliated member of the Branch.

Final Business Session, Friday, November 24, 1933, 12:15 P. M.

Chairman T. J. Headlee called for the reports of the following committees, which were all adopted:

REPORT OF COMMITTEE ON NOMINATIONS

For Chairman, L. A. Stearns, Newark, Delaware.
For Vice-Chairman, T. L. Guyton, Harrisburg, Penna.

C. H. HADLEY
B. D. VANBUREN
GEO. S. LANGFORD

REPORT OF AUDITING COMMITTEE

"We have audited the report of the treasurer and have found it to be correct."

B. A. PORTER
W. J. SCHOENE

Following the acceptance of the above report, the report of the Secretary-Treasurer was adopted.

REPORT OF COMMITTEE ON RESOLUTIONS

The Eastern Branch is indebted to the Academy of Natural Sciences for providing a satisfactory place for this meeting and to its officers and staff for many courtesies rendered; also to the officers of the American Entomological Society for courtesies in arranging the evening meeting and inviting our members to attend. It is recommended that the secretary transmit to each organization a hearty vote of thanks.

The noteworthy efforts of our Secretary-Treasurer and the Finance Committee to manage and finance the operations of the Branch in these days of decline in membership should not be allowed to pass without a word of appreciation and encouragement, and we recommend for them a vote of thanks.

In view of the condition of the treasury we recommend that no papers be published gratis where the authors are in arrears for dues.

C. H. Popenoe of the Bureau of Entomology, died suddenly November 17, at the age of 49 years, leaving a wife and two small children. Although he was not a member of this Branch, most of us knew him, and it seems fitting that his death be placed on record in the minutes of this meeting. We regret that the career of a faithful worker has thus been brought to an untimely end.

W. E. BRITTON
HUGH GLASGOW

Mr. P. M. Eastman, Albany, N. Y., was elected an affiliated member.

The place and time for the 1934 meeting of the Branch was left in the hands of the Executive Committee, with full power to decide.

HARRY B. WEISS, *Secy.-Treas.*

The following members and guests registered during the 1933 sessions:

Allen, H. W., Moorestown, N. J.
Badertscher, A. Edison, c/o McCormick & Co., Baltimore, Md.
Baker, Francis E., Moorestown, N. J.
Balfour, T. G., Louisville, Ky.
Bell, R. H., Harrisburg, Pa.
Birdsall, R. W., c/o Derris, Inc., New York City.
Bobb, M. L., Blacksburg, Va.
Bottimer, L. J., Haddon Heights, N. J.
Brunson, Marvin H., Moorestown, N. J.
Burdette, R. C., New Brunswick, N. J.
Burrell, R. W., Moorestown, N. J.
Campbell, F. L., Takoma Park, Md.
Collins, C. W., Melrose Highlands, Mass.
Crosby, C. R., Ithaca, N. Y.
Courtney, O. K., Philadelphia, Pa.
Darlington, Emlen P., New Lisbon, N. J.
Davis, A. C., Washington, D. C.
Dean, R. W., Poughkeepsie, N. Y.
Dietz, Harry F., Wooster, Ohio.
Dobbins, T. N., Moorestown, N. J.
Dobroscky, Irene D., Glen Ridge, N. J.
Driggers, B. F., New Brunswick, N. J.
Dye, H. W., Middleport, N. Y.
Farley, A. J., New Brunswick, N. J.
Felt, E. P., Stamford, Conn.
Filmer, R. S., New Brunswick, N. J.
Fink, D. E., Takoma Park, Md.
Fischler, Nathaniel, New Brunswick, N.J.
Fisher, H. J., Glenside, Pa.
Fleming, Walter E., Moorestown, N. J.
Fox, Henry, Moorestown, N. J.
Fracker, S. B., Washington, D. C.
Freeman, Ben, Jr., Clemson College, S.C.
Frost, S. W., Arendtsville, Pa.
Gambrell, F. L., Geneva, N. Y.
Garman, Philip, New Haven, Conn.
Gardner, T. R., Moorestown, N. J.
Gemmell, Louis G., New Brunswick, N.J.
Ginsburg, J. M., New Brunswick, N. J.
Glasgow, Hugh, Geneva, N. Y.
Gould, A. C., Albany, N. Y.
Gould, Edwin, Kearneysville, W. Va.
Gwinner, C. C., c/o Crystal Soap & Chemical Co., Philadelphia, Pa.
Guy, H. G., Newark, Del.
Guyton, T. L., Harrisburg, Pa.
Haines, K. A., New Brunswick, N. J.
Hallock, Harold C., Westbury, N. Y.
Hamilton, C. C., New Brunswick, N. J.
Handle, G. K., Trenton, N. J.
Hartzell, Albert, Yonkers, N. Y.
Hartzell, F. Z., Geneva, N. Y.
Hawley, I. M., Moorestown, N. J.
Headlee, T. J., New Brunswick, N. J.
Hill, C. C., Carlisle, Pa.
Hodges, Leigh Mitchell, Acad. Natural Science, Philadelphia, Pa.
Hodgkiss, H. E., State College, Pa.
Horsfall, J. L., New York City.
Hough, W. S., Winchester, Va.
Houser, J. S., Wooster, Ohio.
Huckett, H. C., Riverhead, N. Y.
Hutson, Ray, East Lansing, Mich.
Ilg, Carl, New Brunswick, N. J.
Jobbins, D. Manley, New Brunswick, N. J.
Johnson, J. Peter, Shelton, Conn.
King, J. L., Moorestown, N. J.
Kirk, H. B., Harrisburg, Pa.
Kisliuk, Max, Jr., Philadelphia, Pa.
Koblitsky, L., Moorestown, N. J.
Lewis, C. W., Philadelphia, Pa.
Lipp, J. William, Moorestown, N. J.
Livingstone, Erskine M., Richmond, Va.
MacCreary, Donald, Newark, Del.
MacLeod, G. F., Ithaca, N. Y.
McIntyre, H. L., Albany, N. Y.
Metzger, F. W., Moorestown, N. J.
Middleton, William, Washington, D. C.
Miller, Albert, Ithaca, N. Y.
Moore, Warren, c/o Tobacco By-Products Corp., Richmond, Va.
Moore, Jos. B., Ithaca, N. Y.
Morhead, G. F., Ithaca, N. Y.
Morrill, Austin W., Jr., Richmond, Va.
Murphy, D. F., Bristol, Pa.
Nelson, F. C., Roselle, N. J.
Nelson, R. H., Arlington Farms, Va.
Noble, Harold, c/o S. B. Penick & Co., New York City.

Osburn, M. R., Moorestown, N. J.
Parker, L. B., Moorestown, N. J.
Pearis, L. M., University of W. Va., Morgantown, W. Va.
Pepper, J. O., Harrisburg, Pa.
Pepper, B. B., New Brunswick, N. J.
Pierce, W. Dwight, Philadelphia, Pa.
Phillips, E. F., Ithaca, N. Y.
Porter, B. A., Washington, D. C.
Ressler, I. L., Niagara Falls, N. Y.
Rex, Edgar G., Trenton, N. J.
Richardson, H. H., Washington, D. C.
Roark, R. C., Washington, D. C.
Rolfs, Archie R., Moorestown, N. J.
Schoene, W. J. Blacksburg, Va.
Sherman, R. W., Harrisburg, Pa.
Simpson, G. W., Orono, Me.
Sleesman, George B., Glenside, Pa.
Smith, Charles L., New Brunswick, N. J.
Smith, Floyd F., Washington, D. C.
Smith, Loren B., State College, Pa.
Stearns, L. A., Newark, Del.
Strong, Lee A., Washington, D. C.
Swaine, J. W., Baltimore, Md.
Thomas, C. A., Kennett Square, Pa.
Thomas, W. W., New York City.
Tisdale, W. H., Wilmington, Del.
Trimble, F. M., Harrisburg, Pa.
Turner, Neely, New Haven, Conn.
Van Buren, B. D., Albany, N. Y.
Vreeland, C. D., Little Falls, N. J.
Walker, Harry G., Norfolk, Va.
Weber, Albert L., New Brunswick, N. J.
Weed, Alfred, New York City.
Weigel, C. A., Washington, D. C.
Weiss, H. B., New Brunswick, N. J.
White, R. T., Moorestown, N. J.
Wilcox, H. O., Media, Pa.
Worthley, H. N., State College, Pa.
Wood, H. J., Louisville, Ky.
Woodside, A. M., Staunton, Va.
Wells, A. B., Bryn Athyn, Pa.
Young, H. D., Washington, D. C.
Zappe, M. P., New Haven, Conn.

Papers read November 23, 1933

SOME THOUGHTS ON THE INTERPRETATION OF EXPERIMENTAL DATA

By W. Dwight Pierce, Ph.D.

I am prompted to present this paper because I see passing over my desk so many articles presenting ecological data, which either fail to indicate the value of the records obtained, or wrongly interpret them. Quite frequently an author will present data, and then in his summary will state that because of the contradictory nature of his results, no conclusions can be drawn; and yet in many cases the so-called contradictory data beautifully illustrate some principle, which should be well known.

I wish to confine my remarks to five common types of misinterpretation, or misconception.

1. The use of the hyperbola to express the time-temperature relations.

2. The use of saturation-deficiency in correlation with developmental data.

3. The accumulation of total effective temperature above a fixed zero, ignoring the shift of the zero with humidity and pressure; and ignoring the upper limiting factor, and the time experiencing non-effective high temperatures.

4. Failure to recognize the turn to longer developmental periods at temperatures above the optimum.

And 5. The use of median lethal dosage, instead of absolute lethal dosage.

There is no time permitted me to review the history of the trial by error progress, which has been made in biology, the origins of these and other misconceptions, or the work that has been done to prove them false. I must instead attempt to give the simple, clear argument as to why they are wrong, and what interpretation is more nearly correct.

Every entomologist recognizes the fact that temperature influences the time of every phase of development and activity of the insect; and that there is a point, or series of points on the thermometer scale below which no development takes place. This has been called the Zero of Effective Temperature. I pointed out long ago that the zero shifts with humidity and pressure.

It is highly desirable in every insect study to prepare, at the various mean humidities and pressures experienced in a given region, a series of thermometers of life zones. Reading from the bottom of such a scale we encounter first a cold zone of absolutely fatal temperatures. The upper edge of this zone is the threshold of life. We then have a zone of temperatures which can be endured for increasing periods as the temperature rises. This zone is also a fatal zone, from which there may be escape. Its upper limit is the zero of successful hibernation. The temperatures which inhibit activity and yet preserve life form the hibernation zone. Its upper limit is the zero of effective temperature. The zone of effective temperatures may be divided into many subzones to show the time of a period or phase of life. It will be found that the time becomes shorter continuously up to a certain point, which is known as the optimum. Still in the zone of effective temperatures, those above the optimum lengthen the period. The upper limit of this zone is the threshold of aestivation. The aestivation zone is apt to be rather narrow. Its upper limit is the threshold of death. The zone of death is characterized by ever shortening periods in which life can be endured, and the upper limit of the zone is the point of absolute death.

But we can gain much more information by charting our time data against the temperature data, and this is a very common type of chart.

When you have a considerable series of data at different tempera-

tures, and have taken no account of humidity or pressure, you may chart all of the records, and find a very broad band, with no apparent meaning. But if now you average all of the points at a given temperature, you obtain a curve. This should be checked against a curve made by averaging all of the temperatures producing a given period.

The resultant curve has given some perplexity to those mathematically minded, and four types of curves have been exploited, hyperbola, exponential, catenary and parabola.

In fact Janisch has discussed 6 algebraic formulae, and decided in favor of the catenary and parabola as giving the best fits.

But the simplest and easiest working formulae are the hyperbolic and exponential, and a large number of workers have accepted the hyperbola as a proven fact, and with a limited number of records proceed to extend the hyperbola to its limits. It is all very simple. You only need to establish two points, and then you can derive a zero, and also the complete curve. There are many cases in the literature, and I prefer not to cite any individual case. In Biological Abstracts whenever a writer uses the hyperbola or exponential, or other type of formula for extending his curve we indicate the formula used, so that the reader may know what value to place upon the data. There were certain European writers who have published a number of curves of larval development, in which they show by means of the hyperbola the period up as high as temperatures of 175° Fahrenheit, which is of course quite absurd. I wrote to them suggesting that their tables of development were very misleading, and that their own data indicated an optimum and a parabolic curve, rather than an hyperbola. They answered that the hyperbola formula was so easy to use, and that up to a certain point the data fitted quite closely enough for practical purposes, so they chose to use it, but admitted that I was undoubtedly right in interpreting the data as falling on a parabola.

It is true that with few established points there is a very close fit between parabola, hyperbola and other curves, at temperatures below the optimum. The main difficulty is that too few workers carry their studies above the optimum far enough to determine the parabolic or catenary nature of the curve.

Development does not continuously grow shorter with increased temperature, and hence the use of the hyperbola is absolutely wrong. High temperatures slow up every function, and finally lead to death.

Those who have never lived in hot climates may not realize the slowing effect of heat. Every human faculty is slowed up. And to a much finer degree does heat slow up the insect activity. In Texas you would

see the bees and wasps all asleep during the heat of the day, as well as during the cold of the night. Many species go through two daily sleeps, in hot weather.

In humidities below 50 per cent the optimum temperature is most apt to lie closer to the upper than the lower fatal temperatures. Hence the time-temperature curve usually shows a rapid decrease in the period, with increments of temperature up to a certain point, then a slow decrease, a hesitation, and with added increments of temperature the period begins to increase very rapidly. We are in fact usually dealing with parabolae with diagonal axes.

Now let us pay some attention to the band of data from which we derived the mean curve. In the many cases of published records which I have examined and charted, the established points fall within a parabolic band. We may therefore determine the maximum and minimum periods at any temperature, irrespective of other factors. But the most important consideration is that these bands of data are due to the other variants of the environment, some of which we can determine. The shortest period at a given temperature will be at the optimum humidity-pressure for that temperature, but the longest periods will be due to either high or low unfavorable degrees of humidity-pressure.

I have often noted in entomological literature where one worker has challenged the results of another made at the same temperature, because they differed so much from his own. In all of these cases that I have looked into, the men were working in sections with very different altitude and pressure, or relative humidity.

You are undoubtedly familiar with the psychrometric tables, and know that you must consult the proper pressure table to find the relative humidity in terms of wet and dry bulb temperatures. The three factors operate together upon development.

It is obviously then not enough to gather temperature-time data. We must have temperature-humidity-pressure-time data. Then for each pressure level, chart your data of time as lines against the temperature and humidity factors. The result will be closed concentric curves.

No animal can stand absolute dryness or absolute wetness very long, nor can any animal endure all heats or degrees of cold. There are four bounds to life on a temperature-humidity chart, even though the animal is characterized by extreme propensities.

Hence we may draw an ellipsoidal figure to express the combination bounds of life. Within this will be successive ellipsoids of decreasing periods of development, and the central zone will express the most favorable combination. I have called this central zone the Practicotatum.

Such a chart is of immediate interest because it proves that there is no one zero of development, but that the zero shifts with the humidity.

The same is true of the upper limit.

Such a chart also shows that any temperature scale passes through a series of zones of life reactions; death, inactivity, increasing activity, maximum activity, decreasing activity, inactivity, death.

We immediately see that if we take out and chart only the temperature-time data of a given humidity, we must have a parabolic or catenary curve.

Now if we should make a series of such temperature-humidity charts at a series of atmospheric pressure levels and superimpose them, we will have an ellipsoidal or spheroidal solid, with a void or death zone around it, and within we shall have a series of concentric shells or zones, each representing greater activity, until we reach the heart zone of greatest activity.

If you can conceive of this solid representation of environment you can immediately see that no time-temperature curve can be other than a function of a spheroidal body; and if we chart our time data with but one variable of environment, we cannot get an hyperbolic curve.

A very practical use can be put to such concentric charts. Having determined the bounding zones of activity at the normal pressure level of a locality, you may wish to determine whether the insect can live at a certain other place with like altitude, or normal pressure. It is merely necessary then to chart the temperature-humidity climograph of that other locality, month by month on the insect chart. If the locality shows mean conditions within the developmental zone for a period of months it can then live there and be active in those months.

For example such climographs show that the boll weevil could only be reasonably expected to be able to breed at Tucson, Arizona, in March and April, and September and October, and in no other time of the year. At Giza, Egypt, it could be active from February to the end of November, or perhaps part of December; and in the Nuba Mts. of the Sudan from May to November; but in Ibadan, Nigeria, and on the Philippine Island of Negros it could be active twelve months in the year.

The charting of climographs of extreme temperatures would disclose the possibility of survival of the insect in a given locality. To my mind the time has come when we should begin to correlate the great mass of entomological records along these lines.

Another recent misinterpretation is the attempt to correlate saturation deficiency with developmental and other data. Numerous authors are

accepting this correlation blindly. It is exactly parallel to the hyperbola case. It is quite true that certain data in a certain portion of a chart will fit quite closely to saturation deficiency lines. Wherever this has been claimed I have investigated the data presented and found that there was only a partial correlation, and many records which did not fit. In all of these cases I charted the data as concentrics and found that the curves which took in all data went in opposite directions from the saturation deficiency curves.

Parker's data on the percentage of eggs of *Melanoplus atlanis* hatching at various combinations of temperature and humidity present a series of concentric curves, and do not in reality correlate with saturation deficiency as Buxton has claimed.

And now may I briefly take up my fifth point, the median lethal dose. E. W. Jones has presented data on the median lethal dosage of carbon bisulphide to wireworms of *Limonius*. Fortunately he has also given his other data, and when we chart these we find that the median lethal dosage, or the line of points at which 50 per cent are dead, is not half way to the absolute lethal dose curve. Also we note that at 12° Centigrade there is a great bulge, most emphasized in the last 50 per cent mortality. It leads me to suspect that the optimum temperature lies between 12 and 17 degrees Centigrade, and that when at optimum temperature, the insect has greater resistance to the gas.

But why should we use Median Lethal Dosage at all? In economic entomology we are not seeking to kill 50 per cent, we are seeking to kill 100 per cent. That is our goal, and hence is the most important point to determine.

I wish finally to emphasize the importance of charting all data with as many variations as possible, and to keep on charting as the work progresses. When you have determined three points you have the beginning of a chart, and it will indicate to you where to make your next experiments. Much valuable time is lost by waiting until winter before studying the records of the year. A little time taken from observation to analyse the data already on hand may completely change the course of the remainder of your season's work.

FURTHER EXPERIMENTS WITH PACKAGE BEES[1]

By ROBERT S. FILMER, *Associate Entomologist, New Jersey Agricultural Experiment Station*

Experiences covering ten years have shown the orchards of South Jersey and to a considerable extent in Middle and North Jersey are pollenated primarily by honey bees (1). Repeated observations of the strength of overwintered colonies at the time they are placed in the orchard shows that the average strength colony contains approximately 3 pounds of bees and from 3 to 4 frames of brood (3). Likewise experience has shown that the distribution of one colony of bees per acre gives the best even distribution of flying bees (3). The labor of distributing the colonies uniformly throughout the orchard makes it desirable to use as small a unit as possible and still have the colonies of average strength. The size of the unit is, of course, governed by room needed by the colony during the 10 day period in the orchards. Within these limits the object is to secure the largest number of frames of brood and bees that this unit can handle during the time it will be in the orchard without swarming. As experience has shown (2), the larger the amount of brood, the greater the food-seeking activity of the worker bees and consequently the greater their pollenizing activities.

Experience has shown that from 3 to 4 frames of brood are as much brood as a single storied colony can have at entry into the orchards without danger of swarming by the time of removal. These experiences have led to the standardization of all colonies for orchard work at approximately 3 pounds of bees and from 3 to 4 frames of brood at the time they are placed in the orchard. This problem involves a reduction of brood and bees in some cases and addition in other cases.

Recognizing that overwintered colonies are in many cases below the standard strength, there exists a problem of early building up, and in some cases a purposeful building up, in order that the colony may be divided into two pollenating units of standard strength just before being placed in the orchard. It is with this problem of building up that the present study is concerned.

For this purpose an apiary in the orchard area which contained 46 overwintered colonies was used. The colonies were overwintered in single storied, single walled hives with the entrance restricted by entrance stops. An examination of this yard on April 1st showed that of

[1]Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

the 46 colonies, 5 were dead or queenless, while 41 colonies were queen right and had limited areas of brood. All colonies had sufficient stores of honey although there was a noticeable lack of pollen in some colonies due to poor weather conditions during the maple bloom.

In order to obtaind some criterion of strength, the number of square inches of brood in the various colonies was measured by the following method. A piece of window glass was fitted into a standard size frame with a split bottom bar and a strip of wood tacked over the slot in the bottom board to hold the glass in place. The glass was then marked off in square inches by the use of a diamond pencil. Measurements were taken by placing this frame over a brood frame and tracing the outline of brood area with a wax glass marking pencil. After the area has been determined the outline can be erased with a piece of cloth. It was found by using the unmarked side of the glass and different colored pencils that several impressions could be taken on one glass frame. With a helper to tabulate the brood areas and clean the frames this method is very satisfactory where the brood area does not exceed 4 or 5 frames.

These measurements were later computed as frames of brood by dividing the area in square inches by 272 which represents the maximum possible brood area of a frame.

From measurements of the brood area the colonies were divided into 3 groups as follows:

Group I—Colonies having from 0.5 to 1 frame of brood.

Group II—Colonies having from 1 to 1.5 frame of brood.

Group III—Colonies having from 1.5 to 2 frames of brood.

Several colonies in each group were selected as check colonies while to the remainder of the colonies one pound of package bees was added. The package bees were added by shaking in front of the hive approximately 1 pound of bees. By the use of a pair of household scales the operator had little trouble in shaking out approximately one pound of bees in front of each hive. It was found that shaking the bees just before dusk the bees would readily enter the hive and that there was very little confusion or flying of bees. It might be supposed there would be some danger of colonies having queens killed by introducing bees by this method. Of the 32 colonies treated in this manner, later examination showed only one colony where the queen had been killed or superseded. At the start of the experiment it was expected that the colonies would be placed in the orchards about the 20th of April but due to wet cold weather during the early part of April the blooming period was delayed until the first of May. The colonies were examined on April 18th and the brood area measured, as there was little likelihood of the

TABLE 1. SHOWING THE AVERAGE BROOD AREAS IN FRAMES OF BROOD AT TIME OF EXAMINATION OF OVERWINTERED COLONIES

	Group No.	Number of colonies	Frames of brood April 1	April 18	May 1	Remarks
1. Check—no bees added	I	3	.065	1.3	3.6	Colonies in this group had
2. 1 pound bees added April 4	I	8	.069	2.45	4.86	from 0.5 to 1.0 frames of
3. 1 pound bees added April 4. 1 pound bees added April 18	I	6	.079	2.33	6.4	brood on April 1st
1. Check—no bees added	II	4	1.26	2.3	4.8	Colonies in this group had
2. 1 pound bees added April 4	II	3	1.21	3.2	6.6	from 1.0 to 1.5 frames of
3. 1 pound bees added April 4. 1 pound bees added April 18	II	3	1.23	3.3	7.2	brood on April 1st*
1. Check—no bees added	III	2	1.91	3.0	6.0	Colonies in this group had
2. 1 pound bees added April 4	III	4	1.92	3.9	6.0	from 1.0 to 1.5 frames of
3. 1 pound bees added April 4. 1 pound bees added April 18	III	4	1.90	4.25	8.75	brood on April 1st

*Three colonies stolen during the experiment. One colony queenless in this group.

bees going into the orchards for another 10 days, and an additional pound of bees was added to part of the colonies that had already received a pound of bees. The colonies were next examined on May 1st at which time they were placed in the orchard. The brood counts are found in Table 1.

Examination of Table 1 shows the check colonies in Groups I, II, and III to have 3.6, 4.8 and 6 frames of brood respectively at the time the colonies were placed in the orchard. Of these colonies the first two having 3.6 and 4.8 frames of brood would be considered standard overwintered colonies and on average years could be placed in the orchards with little danger of the colony swarming during the period it would be in the orchard. The check colony in group III which represents in this particular apiary 20 per cent of the total colonies and average 6 frames of brood per colony could not be safely left in a single storied colony during the blossoming period without danger of swarming. In the standardizing of colonies, this colony would be cut to 4 or 5 frames of brood and the remaining brood added to weaker colonies. By this method of standardization the average overwintered colony can safely be handled in a single storied hive, which is not only convenient from the beekeeper's point of view but also insures the orchardist of uniform colonies of average strength.

Examination of colonies in Groups I, II, and III which received 1 pound of bees on April 4th showed that on May 1st when colonies were placed in orchards the average frames of brood per colony were 4.86, 6.6 and 8.5 frames of brood respectively, a gain over the check colonies of 1.2, 1.8 and 2.5 frames of brood by the addition of 1 pound of bees on April 1st. From these figures it can be seen that colonies in Groups II and III can be divided so as to make 4 colonies having an average of 3.5 frames of brood which is comparable with the check colonies in Group I. Of course, in such cases queens would need to be introduced in order to insure normal activity.

Examination of the colonies in Groups I, II and III that received 1 pound of bees on April 4 and 1 pound on April 18 show them to have brood areas on May 1st of 6.4, 7.3 and 8.75 frames of brood respectively, a gain over the check colonies of 2.8, 2.4 and 2.75 frames of brood. The gain due to the addition of the second pound of bees is 1.6, 0.6 and 0.2 frames of brood in each case. From these results it is very noticeable that the pound of bees added on April 1 had a greater stimulating effect on brood rearing over a ten-day period than the pound of bees added on April 18th had over the same period of time.

It is interesting to note the comparative brood areas of 10 3-pound packages which were established on April 4, and 5 of which received 1 pound of bees on April 18th. The results are shown in Table 2.

TABLE 2. AVERAGES OF BROOD AREA IN FRAMES, 10 3-POUND PACKAGES ESTABLISHED ON APRIL 4TH—FIVE OF WHICH RECEIVED 1 POUND OF BEES ON APRIL 18TH

	Number of Colonies	Brood on May 1st
Checks	5	4.5
1 pound bees added April 18	5	5.0

Examination of Table 2 shows that 3-pound packages established on April 4 had sufficient brood area to make them comparable to average overwintered colonies.

CONCLUSIONS.—Although these experiments are of a preliminary nature and favorably influenced by a delayed blooming period, the results seem to justify the conclusion that the stimulating of brood rearing in overwintered colonies by the addition of package bees and the later division of these colonies is a practical method of obtaining additional pollenating colonies of average strength.

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SHADE TREE INSECTS IN 1933

By E. P. FELT, *Bartlett Tree Research Laboratories, Stamford, Connecticut*

The past season has seen unusually severe injury by several leaf eating pests and a decided increase in injuries to pine tips by several borers.

The earliest and to a certain extent the most spectacular of the outbreaks was that of the fall canker worm (*Alsophila pometaria* Harr.), a species which, for some reason or other, appears to persist in greater or less numbers in an area in southwestern Connecticut, southern Westchester County, N. Y., and on the western end of Long Island. Apparently climatic conditions in portions of this region at least, are decidedly favorable to this pest. The outbreak of 1933 was unprecedented or nearly so, since it resulted not only in the defoliation of many shade

trees, but in practically denuding square miles of forests, almost every tree losing its leaves. The devastation was so complete that practically winter conditions, so far as leafage was concerned, were observed in June at the time when the trees should have been at their best. It is quite probable that the pest will be less abundant next year in the areas where it was so destructive last spring, although the indications are that canker worms will be numerous in sections bordering the area of greatest damage last spring.

The elm leaf beetle (*Galerucella xanthomelaena* Schrank) has been unusually abundant and destructive in the northeastern United States for several years past and, as earlier, the depredations were confined largely to trees in cities and villages. There was a marked exception in that in southwestern Connecticut at least there were several localities where this insect had actually invaded the woodlands and stripped elms in swamps just as thoroughly as those upon the highways. This has not heretofore come to our attention, though it may have been observed by others. It was also noted that elms which had been defoliated earlier by canker worms were not fed upon to any extent by the elm leaf beetle. There was evidently too little foliage available at the time the beetles were abroad and laying eggs and the insects either died or made their way to more promising feeding grounds.

The Japanese beetle (*Popillia japonica* Newm.) continues to be a serious pest in the Philadelphia area, though the damage does not seem to be so great as during the last few years. It is probable that this territory is reaching the status of that known as the "older infested area" and some reduction in the abundance of the pests and the amount of injury may be expected, though it is not likely that this will come anywhere near to approaching a moderately satisfactory freedom from infestation. It is gratifying to state that local infestations by this insect at Stamford, Conn., do not appear to have increased greatly, although there are other localities in Connecticut where the insect is becoming numerous. There have been in the Philadelphia area at least, a number of cases where lawns have been very seriously damaged or even ruined by the grubs of this insect.

The willow leaf beetle (*Plagiodera versicolora* Laich.) continues its role as a serious willow pest, its three broods keeping the foliage of badly infested willows in an unsightly grayish-green or brown condition throughout much of the season. It has been responsible for the serious weakening and near destruction of many magnificent trees, though the

willow scab fungus (*Fusicladium saliciperdum*) has proved much more deadly, killing literally thousands of trees, especially in the Berkshires.

The gipsy moth (*Porthetria dispar* Linn.) should be mentioned in this connection, since it has been increasing in numbers, particularly in southeastern Massachusetts, and in addition there is the considerable infested area in Pennsylvania. This last is beyond the Barrier Zone, and it is highly desirable that there be actual extermination, otherwise the protection afforded by the Barrier Zone will be largely destroyed. The gipsy moth is one of the more important introduced pests, since it feeds freely upon a considerable variety of trees and shrubs, and when allowed to multiply unchecked is capable of defoliating extensive areas.

The larch case bearer (*Coleophora laricella* Hubn.) has continued abundant over large areas, including extensive forest sections, and caused a general browning of the foliage.

These six insects, and other unmentioned species of less importance, are causing annually serious injuries to literally millions of our shade and ornamental trees. These ravages appear to be on the increase, and even if certain of these species become less numerous, there is an excellent probability that their places will be taken by other pests, and as a consequence we must assume that systematic protection of shade trees from leaf eating insects is becoming more necessary as the years go by. The fruit growers have been compelled to provide systematic protection for their trees from leaf eating insects, and it is only a question of time before those really interested in shade trees will find it necessary to adopt a more or less comprehensive program for the suppression of these pests.

A decidedly unusual condition was found early in May on certain pin oaks at Rye, N. Y. The galls of a cynipid (*Andricus coronus* Beutm.) were so abundant that very little of the foliage remained uninfested. The leaves were mostly represented by masses of galls, which dropped in large numbers the middle of May.

Enemies of pine tips are now attracting attention on account of their abundance and the diversity of the injury.

The very common and somewhat well known white pine weevil (*Pissodes strobi* Peck) has temporarily been eclipsed, at least to a certain extent, by more recent introductions or an unusual abundance of species previously attracting little notice.

The introduced European pine shoot moth (*Rhyacionia buoliana* Shiff.) has been excedingly destructive in recent plantings of pine, especially red pine and Scotch pine, and in some instances the trees on

considerable areas have been practically destroyed. It may be noted in passing that spraying with a nicotine, oil and arsenate of lead combination at the time the moths are in flight and egg laying is in progress, has given very satisfactory control. Such treatment is obviously impractical in the case of average forest plantings.

The Nantucket pine moth (*Rhyacionia frustrana* Comst.) and the closely related *R. rigidana* Fern. have become unusually numerous in certain localities. The former is a well known and general pest on the Island of Nantucket and has been reared in numbers from shoots of pine in the Philadelphia area. The latter species is also somewhat prevalent, both producing in midsummer very similar appearing, brown terminals some three to four inches long. These insects may be controlled in the same way as the European pine shoot moth, provided the sprays are timed to accord with the flight and oviposition periods of the moths.

The comparatively unknown white pine shoot moth (*Eucosma gloriola* Hein.), recently found in southern New England, has become more abundant in that section and is well established in southeastern New York and has been reported from the Adirondacks. This insect works almost entirely in the lateral shoots, infesting 20 or more on trees possibly 30 feet high and killing back a portion six to eight inches in length, although an occasional, somewhat weak leader may also be destroyed. Otherwise it is very easy to distinguish between the work of this insect and that of the white pine weevil. The whitish caterpillars, of this species bore in the center of the shoots. They desert them before there is any appreciable foliage discoloration and winter in the soil. No practical control measure is known.

The pine tip beetle (*Pityophthorus pulicarius* Zimm.) has been given this common name because it confines its operations very largely to pine tips, especially Austrian pine. Some three or four inches of the dead branch are marked by brown needles, and an examination in midsummer results in finding the tiny beetles approximately a sixteenth of an inch long in small burrows or galleries. This insect works not only in the tips but when abundant may penetrate to some distance in the branch, and in the case of a serious infestation may kill a large number of tips and destroy individual branches, and in extreme cases a considerable portion of the tree. Severe work of this character has been observed in southern Westchester County, N. Y., on eastern Long Island and also in the Philadelphia area. It is probable that the development of this insect has been greatly favored by the dry seasons of the last few years reducing the vitality of the trees to a marked extent. The wintering habit of this species is unknown.

The borers deserve a brief notice, since there have been a number of interesting developments.

The well known leopard moth (*Zeuzera pyrina* Linn.) becomes locally abundant here and there, and in the spring of 1932 a general infestation was observed on Nantucket Island. Trees were gone over carefully, and the more badly injured branches trimmed out and burned. In addition the trees were carefully examined for evidence of recent borings, and each inhabited gallery treated with a borer paste, a commercial preparation recently placed upon the market. The paste is simply forced into the outer part of the gallery and the borer in attempting to clean out its burrow later becomes smeared with the material and succumbs. The efficacy of this treatment depends very much upon the thoroughness with which the work has been done. It is gratifying to state that very satisfactory results were obtained from this operation.

The two-lined chestnut borer (*Agrilus bilineatus* Web.) continues to be a serious pest not only in ornamental but also in forest trees. The dry seasons of the last few years appear to have been exceptionally favorable for this insect, and here and there, notably on Long Island, in the Philadelphia area and near Wilmington, Del., one may find woodland areas with groups of trees in a dead or dying condition. Obviously the badly infested trees should be cut and burned in order to prevent the insects issuing and attacking others nearby. A considerable degree of protection from this insect may be obtained by spraying with arsenate of lead the last of May or early in June.

The story is somewhat similar in relation to the hickory bark beetle (*Scolytus quadrispinosus* Say). Here and there may be found groups of hickories with some trees badly infested. The experience of the last year has abundantly demonstrated the practicability of locating the badly infested trees and cutting them out. This, supplemented by feeding to stimulate a vigorous growth, and by spraying with arsenate of lead at the time the beetles are abroad and feeding, have resulted in very satisfactory control. It is obvious that such measures can be recommended only in the case of the more highly valued shade or grove trees.

A limb pruner (*Xylotrechus quadrimaculata* Hald.) was somewhat abundant last spring in a European beech hedge at New Canaan, Conn., and also on other beech in the vicinity. In the case of this hedge there were possibly five per cent of the branches cut off, some of them having a diameter of two inches. The work of this insect was also observed on Long Island and at Wenham, Mass.

Locust borers (*Cyllene robiniae* Forst.) have been unusually prevalent in the Poughkeepsie, N. Y., area, badly infested trees showing a wilting

and drying up of the foliage, due presumably in large part to borer damage.

The spotted hemlock borer (*Melanophila fulvoguttata* Harr.) has been killing hemlocks at Greenwich, Conn., and in southern Westchester County, N. Y., in both cases it is probable that the insects were greatly favored by a reduced vitality following a series of dry years, and in the case of the Greenwich trees these were growing in lawns where drought conditions would be still further accentuated. Weak or dying tops are usually the first indication of infestation by this cambium borer. A little judicious exploration with a chisel is relatively easy and gives a good idea as to whether the tree is so generally infested as to be beyond hope. This latter is altogether too frequently the case.

The more we see of these cambium borers and their work, the more we appreciate the importance of preventive measures, such as feeding and spraying, in order to keep the trees growing vigorously.

It may be well to emphasize at this time the relation existing between certain insects and fungous diseases. One was brought to attention last winter. It has been established by pathologists that an infestation by the introduced beech scale (*Cryptococcus fagi* Baer.) produced very favorable conditions for infection by *Nectria coccinea*, an introduced disease reported as infecting 90 per cent of the beeches over three inches in diameter in forest stands in the Canadian Maritime Provinces, 50 per cent being killed in localities where the attack has continued for several years. The insect and the disease are known to be established in a number of Maine localities, and the insect has been found in eastern Massachusetts.

FURTHER OBSERVATIONS ON MUSHROOM INSECTS[1]

By C. A. THOMAS, *Pennsylvania State College*

During the past two seasons mushroom pests have apparently been on the increase, favored perhaps by the unusual weather conditions, which have caused much wet manure to be placed in the houses. Several insects not previously recorded as mushroom pests have caused some injury in the Pennsylvania mushroom district. The general methods of handling the manure piles outdoors, and after filling the houses, have been discussed in previous publications.[2] The present paper deals with

[1]Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station, November 18, 1933, as Technical Paper No. 618.

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[2]Pennsylvania State College Bulletin 270, October, 1931; Journal of Economic Entomology, April, 1932, pp. 322–331.

new control measures or commercial application of some methods which had previously been tried only experimentally.

As noted in the above papers, most of the pests enter the houses in the manure. They enter the manure piles from the soil of the composting ground and from nearby piles of new manure and old compost. The great abundance of springtails in the piles this past fall was largely due to the heavy rains which wet the manure, thus making it very attractive to them.

In several experiments, canvas or heavy building paper was placed over the surface of the pile; this caused the manure to heat to the surface and drove many springtails, mites, etc., up under the cover. In small experimental piles, high percentages of kill were obtained by rolling back the canvas, lightly broadcasting calcium cyanide, spraying or dusting nicotine compounds or pouring small amounts of carbon disulphide onto the manure surface. The canvas was immediately replaced to retain the gases. These treatments were made two days before the manure was placed in the houses, and the canvas was removed and the manure allowed to air at least one day before placing it in the houses, in order that the workmen would not be exposed to the gas. As these treatments have been tried only on small piles it is impossible to tell their value for a whole house, but in these experiments most of the exposed insects were killed, and the mycelium has run well in the treated manure.

The insects, especially the springtails, usually appear first on the top beds, driven to the surface by a subsurface temperature of 125° F. or more. If the bottom beds can be made to heat, as by raising them a few inches and using fans in the aisles, they may also become hot enough that the springtails there are driven to the surface. A light sprinkling of water on the bottom beds during the heating has occasionally helped to bring these insects up onto the surface, but generally cannot be used.

In several houses where the manure attained a temperature of 135° to 140° F. the springtails were practically all killed by the heat alone. In most instances, however, the manure heat is not sufficient to kill them, and must be supplemented by cyanide or sulfur fumigation. One-half pound of calcium cyanide per 1000 cubic feet of air space seems to be sufficient if the springtails are actually exposed to the gas. Many growers waste fumigants, however, by fumigating when there are actually few or no insects on the manure surface. These fumigants will not penetrate far enough into the manure to kill many insects there. The aisles should be thoroughly cleaned before fumigation, as manure lying there protects the insects from both the heat and the fumigants.

SPRINGTAILS.—Where the springtails have not been killed by the above methods they frequently attack the spawn piece as soon as it is placed in the bed. The moisture and odor of the mycelium are very attractive to the springtails, and they congregate in the spawn piece to feed on this mycelium, and may entirely destroy it. Occasionally replanting is necessary, but frequently they feed for a few days then desert the spawn piece. If any mycelium remains, or if the grains are not too much dried out, it still has a chance to grow and produce a crop. Springtails rarely bore into the grains of the grain spawn, but feed on the outside of the grains. They may carry molds into spawn.

In detecting and controlling these springtails, use was made of their strong phototropic and hydrotropic reactions. To detect their presence in the spawn piece, it was only necessary to uncover the piece, place a piece of paper against the spawn, and place a light at the other end of the paper. If any springtails were present, they immediately crawled toward the light. If control was deemed necessary, the next step was to warm the house somewhat, then lightly sprinkle the manure surface with water. Within a few hours the springtails came up into this moist area in immense numbers. Satisfactory kill was then obtained by any of the following methods:

1—Evenly broadcasting about one pound of a high nicotine content fumigating powder over the surface of each 60 foot bed. This method was much more effective than the usual greenhouse procedure of burning the powder in the aisles, for by the latter method the gases seemed to be much more toxic to the springtails on the lower beds than to those on the top beds.

2—Lightly dusting the bed surface with a 2 or 3 per cent nicotine-lime dust.

3—Lightly spraying the bed surface with 3 or 4 teaspoonfuls of free nicotine per gallon of water.

Pyrethrum powders, powdered derris and rotenone dusts are only partially or slowly effective to these springtails, and cannot compare with the nicotine compounds for this purpose. Springtails on the aisles are rapidly killed by naphthalene broadcast on them. After a couple of hours this should be removed from the house, and none should be allowed to fall on the beds.

The springtail chiefly concerned in the above destruction of the spawn piece has been identified by Dr. J. W. Folsom as a *Proisotoma* species very close to *P. thermophila* (Axels.). *Achorutes armatum* Nic. and *Lepidocyrtus cyaneus* Tullb., although common this year, have generally been much less destructive than the above species. The large, active,

buff-colored *Lepidocyrtus lanuginosus* (Gmel.) Tull. has caused some injury in several houses near Reading, Pa., and much injury at Barberton, Ohio, by making holes in mushroom caps and stems. Control was obtained by heavy nicotine fumigations. This species is negatively phototropic to artificial light.

PHORIDS.—Considerable injury has been done to newly-planted spawn pieces by larvae of the Phorid flies, *Megaselia* (*Aphiochaeta*) *agarici* Lintner. This injury is very similar to that caused by springtails, and most of it is done within a few days after the planting, when the larvae move in from the adjacent manure. They may tear this spawn to pieces, but if the mycelium can become established in the surrounding manure it may continue to grow unchecked by their feeding. Otherwise it is usually necessary to stimulate the mycelial growth by keeping the house temperature at about 70° to 75° F. This also hastens development of the larvae into the pupa stage, when feeding stops. This pupa stage occupies at least two weeks, so that the mycelium can become well established before any new larvae enter the manure, and after the mycelium is well established in the manure, further feeding by these larvae rarely causes much injury.

Large numbers of these Phorid larvae sometimes appear on the casing soil after the beds are watered, and pupation may even occur there. Nicotine or pyrethrum dusts or sprays, applied to the bed surface, may kill many of these and other dipterous larvae on the bed surface. Although Phorid larvae are usually not so injurious to the growing mushrooms as are Sciarid larvae, they sometimes cause similar injury by boring up the stems and into the caps. This usually is most common either at the beginning of the fall crop, or in the warm weather of late spring. Since no insecticides affect these larvae inside the mushrooms, it is necessary to raise the house temperature somewhat, thus causing the larvae to go down into the beds to pupate, as pupation seldom occurs within the mushroom. Close picking and destruction of the infested mushrooms also helps. When raising the temperature it is necessary to remember that the higher temperatures are also favorable to the growth of Mycogone and other mushroom diseases.

In controlling the adult Phorids, it has been found that pyrethrum dusts are not so effective as they are to Sciarid flies. On the other hand a dosage of calcium cyanide as low as one-fourth ounce per 1000 cubic feet of air space has given a good kill of those Phorids which were exposed to the gas. This gas does not penetrate far into the beds to kill the flies there, so it is necessary to raise the temperature somewhat for several hours before the fumigation, and keep it up during the fumigation.

This activates the flies and brings them out of the beds, and also helps to prevent condensation of moisture on the mushrooms and consequent burning. Mushrooms should always be dry during cyanide fumigations. It is not recommended that cyaniding should be frequently repeated in a bearing house, as it is a dangerous job for the inexperienced, and it is usually not necessary if it can be supplemented by pyrethrum dusting. Nicotine fumigants will kill many of these flies, but there is usually some recovery and only high nicotine content fumigants should be used. Spraying liquid nicotine fumigants on hot pipes has given a good kill in some houses.

SCIARID FLIES.—Like the Phorid larvae, Sciara larvae may feed in and destroy the newly-planted spawn pieces. Warming the houses will hasten the mycelial growth and stimulate development of the larvae to the pupal stage. The pupa lasts about a week. Dusting should begin as soon as the first flies are seen, as the females can begin to lay eggs within a day or two after emerging from the pupa. Hydrocyanic acid gas does not seem to be so toxic to the Sciarid flies as to the Phorids. Good grades of pyrethrum powder, composed of a carrier plus pyrethrum flowers or extracts, are still the standard controls for Sciara flies. These dusts are actually toxic to these flies when the dusts are on the beds even seventy-two hours after the dusting, and counts in many houses have shown that many more flies actually die in the second twenty-four hour period after dusting than died during the first few hours, when the dust was still floating in the air. This means, first, that the flies activated by the warmth are coming out of the beds some hours after the dusting and are then affected, and second, that the flies are affected by the dust as they contact it on the beds. On the other hand, while HCN gas may kill the Sciarid flies that are exposed to it at the time of application, it soon dissipates, leaving no toxic residue upon the beds. Therefore it must be repeated to obtain the same final kill as is obtained by one application of pyrethrum dusts. Tests of a steam vaporizor for vaporizing pyrethrum extracts into the air showed that it would give a good kill, but, like the cyanide, little or no residue remained upon the beds and the vaporizing had to be frequently repeated. There was no apparent injury to the mushrooms from the use of this material.

Nicotine dusts have value against these flies, but are still in the experimental stage. Rotenone dusts kill some flies, but seem to be much slower in action than pyrethrum dusts, and heavy dosages of proprietary rotenone compounds placed in the manure were ineffective against insects there; perhaps these compounds are affected by the alkalinity of the manure.

In addition to feeding in the spawn pieces the Sciarid larvae frequently destroy much of the mycelium growing through the manure, and chew the manure into damp, broken-down granular material. If any of the mycelium remains after the larvae have pupated, and if the manure is not injured physically too much, the mycelium may again grow into these areas and sometimes produce a good crop despite the injury. The pH of the manure in these injured spots generally is above 7, perhaps due to the alkaline feces of the larvae.

The boring of the stems and caps by Sciarid larvae usually begins later in the fall than that caused by Phorid larvae, and may continue throughout the winter. The tiny "pin-head" mushrooms appearing on the soil may be killed off in large patches, being honey-combed or hollow, and yellowish. Sciarid larvae also appear occasionally on the casing soil after watering and usually may be controlled by pyrethrum or nicotine dusts or sprays. Growers sometimes apply hydrated lime to the soil surface to control these larvae. Experiments show that when these moist-surfaced larvae come in contact with any really dry substance, including hydrated lime, they rapidly become dry on the surface and desiccation sets in, due to absorption of the moisture by the dry dust. If the lime becomes moist by absorbing water from the soil surface, however, the larvae are very little affected by these moist particles. As most of the larvae occur on the soil surface only when the soil is quite damp, it is evident that much of the value of the hydrated lime is wasted, so far as its effect on the larvae is concerned. Pyrethrum and other truly toxic dusts and sprays, which do not depend on their drying power, have much more value than hydrated lime.

Frequently when Sciarid flies are dying, either naturally or from the effects of insecticides, they exude strings of eggs, due to contraction of the abdominal muscles. Only the outer two or three eggs of this string are liable to hatch, however, for most are not fully developed, and they soon dry up. Even when the eggs are laid naturally, the larvae are somewhat cannibalistic when they contact; those which have been bitten usually succumb to fungi or bacterial diseases. An undetermined red bacterium has been noted affecting Phorid larvae. Adult Sciarid flies, under warm humid conditions, sometimes are attacked by a fungous disease resembling the Empusa of house flies.

CECIDOMYIIDS.—During the past fall there has been considerable injury by Cecidomyiid larvae, especially in the vicinity of Oxford, Pa. The species involved have not been determined, but the larvae are very small, slender, white or yellowish, and have a tiny, black, bird-like chitinous plate inside the thorax. These larvae feed at the base of the

mushroom, cutting out the tissues and destroying the mycelial "roots" until the mushroom may be held to the soil by only a single strand, and its growth either stops or is seriously hindered. They also burrow just under the surface of the upper stem, the under part of the cap, and into the gills, in immense numbers, causing the tissues to become orange colored or brownish, and slimy, and affording entrance for diseases. They do not make burrows up through the stems and caps in the manner of the Sciara and Phorid larvae.

At times these larvae also appear in immense numbers on the moist bed surface after watering, and may congregate in groups of many intertwined individuals. Pyrethrum dusts and sprays are effective against these larvae when they actually contact them, but may have to be repeated several times. Since these insecticides do not affect the larvae under the stems or in the caps, it is necessary to pick the mushrooms quite closely before applying the insecticides. The frail, orange-bodied adults are easily killed by pyrethrum dusts, but, strangely enough, they seldom appear in numbers comparable to the abundance of the larvae. This may be partly because these larvae are at times paedogenic, producing larvae directly from themselves rather than proceeding through the normal pupal, adult and egg stages. This may account for the enormous and rapid increase in number of these larvae without the appearance of many adults.

OTHER DIPTERA.—In addition to the flies discussed above, the following are also sometimes found in mushroom houses:

1—*Forcipomyia cilipes* Coquillet (Family *Chironomidae*). The peculiar whitish larvae of this small fly occasionally occur in small groups in the beds, especially along the sides behind the boards. They may eat some mycelium but have not been seen to cause extensive injury.

2—*Rhegmoclema* sp., probably *atrata* Say. The tiny brownish larvae have several times been found feeding in the grain spawn, but this is not a common occurrence, and they are not major pests of cultivated mushrooms.

COLEOPTERA.—*Litargus* sp. (Family *Mycetophagidae*). These small black and yellow beetles have recently caused some injury at Hershey, Pa., by eating holes into the caps and stems of small mushrooms. Previously they have been recorded only from wild mushrooms.

Aphodius fimetarius L. (Family *Scarabaeidae*). This small black and red dung beetle has been noted occasionally in mushroom beds in coal mines in western Pennsylvania, but their injury, if any, has not been determined. This species is on record as having injured mushrooms in Europe.

MITES (ACARINA). A number of species of mites inhabit the mushroom house, mostly entering with the manure when the beds are filled. If the manure attains a heat sufficient to drive them to the surface, they may then be killed with Hydrocyanic acid gas or especially with gas from burning sulfur.

Manure composted on concrete floors outdoors is generally less infested with mites and springtails than that composted on the ground. After the manure is in the house, and if the above procedure does not kill them, mites may get into the spawn piece and eat the mycelium out or may even bore into and destroy the grains of the grain spawn. The chief species involved in this type of injury has generally been *Rhizoglyphus phylloxerae* Riley (identified by Dr. H. E. Ewing, U. S. National Museum). If they occur in the spawn piece and cause much injury, they will not leave the piece if the bed surface is moistened, as do the springtails, nor will warming the house force them into non-feeding stages, as with the fly larvae. If the mycelium grows out into the surrounding manure it is usually able to go on and produce a crop, but if the mites destroy the spawn piece before the mycelium gets into the manure, the spawn may, in a few places, have to be replanted. If this is necessary, it is always best to plant the new spawn pieces midway between the old pieces, rather than in or near the old pieces. In this way the new spawn has a chance to grow into the beds and get established, for the mites will seldom leave the food and moisture of the old piece to attack the new spawn.

Rhizoglyphus phylloxerae, Histiostoma gracilipes, and *Tyroglyphus lintneri* Osborn may all occasionally be found attacking the growing mushrooms on the beds. Few insecticides will affect them without also injuring the mushrooms, and sprays containing oils or soaps, although possibly toxic to the mites, should be kept away from the mushrooms. Laboratory studies have shown that strong nicotine dusts, in actual contact with *Tyroglyphus* adults, will kill many of these mites. The injury by *R. phylloxerae* and *H. gracilipes* usually consists of lesions and chewed tissues at the base of the stems, making the latter quite constricted and held to the bed by only a few threads. *Tyroglyphus lintneri* also makes quite large holes into the caps, as described in Pa. State College Bulletin 270.

The Long-legged Mite, *Linapodes antennaepes* Banks has not been very common or destructive during the past year.

The very active "Red Spiders" or Gamasid mites sometimes appear in enormous numbers on the beds while they are in heat and for a short

time afterward, but soon disappear so that normally they are less common on the beds during the time they are in bearing. Since Gamasids feed on other mites and on springtails, they are more beneficial than harmful.

A heavy infestation of mites in a bearing house was cleaned up by first removing all of the marketable mushrooms, then removing and destroying all infested mushrooms which it was possible to pick. Finally the soil surface was thoroughly cleaned with a furniture vacuum cleaner equipped with a brush. The picked-up material was sprayed with kerosene outdoors and burned. Few mushrooms were infested after this cleaning.

REPORT OF THE COMMITTEE ON EUROPEAN PINE SHOOT MOTH CONTROL APPOINTED BY THE CHAIRMAN AT HEARING IN NEW HAVEN

Inasmuch as the European pine shoot moth (*Rhyacionia buoliana* Schiff.) has caused severe injury to forest plantings of Red and Scotch pine in the south-western portion of Connecticut, the south-eastern and western portions of New York and the southern part of the Province of Ontario in Canada and has become one of the foremost forest pests in these regions and inasmuch as the insect is believed to be generally distributed on ornamental pine plantings throughout north-eastern United States, it is strongly recommended that some action be taken to protect forest plantations and to prevent further distribution of this pest.

This insect has one generation each year. The adults fly during June and July and lay their eggs on the host trees, close to the tips of the branches. The larvae hatch during the latter half of June and in July and bore into the bases of the needles at the tips of the branches. Later in the summer, they bore into the terminal buds and there pass the winter. The presence of the larvae during the fall months is indicated by dead needles and masses of pitch on the bud clusters. In the spring the larvae bore into the young shoots, causing an extensive pitch flow and the distortion and death of said shoots. The larvae become full grown in May and June and pupate in their tunnels in the shoots. The peak of the adult emergence occurs during the latter part of June. The insect spreads rather slowly unless transported on infested stock.

The injury which this insect causes to infested pines consists of the killing of the terminal growth, with resultant stunting of the tree, and on heavily infested trees, it is very severe. Entire plantations have been rendered valueless and several acres of Red pine in Connecticut have been cut and burned because of the injury caused by this pest.

Control measures against this insect consist of the clipping and burning of the infested tips, usually between September and the following June; spraying, accord-

ing to recommended formulae, between the middle of June and the middle of July; and the destruction of heavily infested host plants, which are injured beyond the possibility of recovery.

Quite systematic inspections that have been made in the infested areas, though rather limited in their scope, offer convincing evidence that severe shoot moth infestation in forest plantations is a localized condition of a rather limited nature. Control experiments conducted by several states during the past few years encourage the belief that control practices are feasible and can be effectively applied.

With this understanding, this committee respectfully recommends consideration of the following points:

(1) That states provide for additional inspection and control measures by clipping and spraying to insure freedom from infestation in nurseries.

(2) That owners attempt to control the insect in forest and ornamental plantings by clipping, spraying and destroying the badly injured stands.

(3) That states provide for a survey of ornamental plantings for the purpose of determining the presence or degree of infestation and for the purpose of eliminating infestation in cooperation with the owners.

(4) That each infested state establish intra-state restrictive regulations wherever it seems advisable to prevent infestation over its entire territory.

(5) That all states involved in the shoot moth problem promulgate new, or amend present, regulations concerning the transportation of plants by peddlers. Heavy fine, imprisonment, or both should be the penalty for any one caught with infested plants, or plants unaccompanied by a proper certificate of inspection.

(6) That the Bureau of Entomology of the United States Department of Agriculture be requested to make a survey for the purpose of ascertaining the present distribution of the insect in the United States as a basis for the establishment of restrictive regulations to prevent the shipment of susceptible pines into forest regions not now infested, also that the parasite work be continued.

(7) That the Bureau of Plant Quarantine of the United States Department of Agriculture be requested to consider the advisability of determining zones or areas which are infested, and of establishing restrictive regulations prohibiting the shipment of all pines out of these zones or areas between June 1st and September 1st, and for the remainder of the year except when accompanied by a certificate of freedom from infestation, signed by an authorized federal or state inspector, and based on an inspection just before shipment.

Respectfully submitted,

H. L. McIntyre
W. E. Britton
R. H. Allen

WINTER SURVIVAL OF THE POTATO TUBER MOTH *PHTHORIMAEA OPERCULELLA* ZELL.

By GEORGE S. LANGFORD, *University of Maryland*

In studies on the potato tuber worm under Maryland conditions, the writer has attempted to ascertain the influence of winter temperatures on the survival of the various stages. The results reported deal only with the temperatures that might be encountered in open, but sheltered, locations such as an open insectary. They do not give consideration to the several other factors which influence winter survival.

The studies of Underhill[1] and Poos and Peters[2] have contributed valuable information on winter survival of the potato tuber worm under Virginia conditions. The writer has endeavored to gather information on conditions as encountered in Maryland. It is known that under conditions of common storage small numbers of the potato tuber worm survive the winter, but from all appearances the pest does not, in the true sense of the word, hibernate in Maryland. The potato tuber worm has been observed to be present and active in practically all stages of its development throughout the year. However, low temperatures do retard and quite frequently cause a temporary cessation of development. Indications are that the destructive effect of low temperatures on the food supply is a significant factor in the survival of the insect. This assumption is based on the fact that the insect in all its stages can survive relatively low temperatures and continue to develop during subsequent warm periods. This assumption is somewhat further substantiated by the work of Poos and Peters. They reported that a period of seven months was required for the development of adults from larvae stored with potatoes in an unheated cellar. If the food supply could be maintained, development would probably continue in the field throughout the winter with fewer fatalities.

The low temperatures which are fatal to the different stages of the tuber worm are not known with exactness. Numerous instances are recorded where the different stages survived temperatures ranging from 11° to 20° F. Prolonged exposures to low temperatures are apparently fatal to all stages. An exposure to a temperature of 2° F. for a period of 24 hours was fatal to all stages except the egg.

[1]Underhill, G. W. "Studies on the Potato Tuber Moth During the Winter of 1925–1926." Va. Exp. Sta. Bul. 251. (1926).

[2]Poos, F. W., and Peters, H. S. "The Potato Tuber Worm." Va. Truck Exp. Sta. Bul. 61. (1927).

It is not uncommon for individuals of the different stages to live long periods and continue development during warm days under the fluctuating temperature conditions as encountered in the open insectary at College Park.

The length of time required for eggs to hatch depends on the temperature. Eggs have been held 85 days before they hatched. A few experiments as listed below indicate the length of the incubation period in the insectary at College Park during the winter of 1931–1932:

1. Eggs laid December 1 hatched January 25 or after 55 days.
2. Eggs laid December 23 hatched February 28 or after 65 days.
3. Eggs laid January 11 hatched March 29 or after 78 days.
4. Eggs laid January 20 hatched April 14 or after 85 days.
5. Eggs laid February 3 hatched April 15 or after 72 days.

The above data indicate that, theoretically, it might be possible for the insect under suitable storage conditions to pass the winter in the egg stage. However, eggs held in cold storage for a period of four months at a temperature of from 35° to 40° F. failed to hatch.

In the absence of food immature larvae have not been observed to live through the winter months. All partially grown larvae placed under observation in November and December died prior to April 1. However, the work of Underhill shows that individual larvae may live over winter in the vicinity of Bayford, Virginia. Experiments have shown that many individual immature larvae under insectary conditions at College Park will withstand exposure of from 15 to 20 days at temperatures fluctuating between 15° F. to 50° F., and if then transferred to room temperature and given food they will continue their development and mature. Newly hatched larvae held at the above temperatures without food have lived thirteen days and retained sufficient vitality to enter potatoes and complete their development when removed to room temperature. Experimentation was not continued after this exposure.

Of the different stages of the insect, individuals entering the winter as full-grown larvae appear to survive in the greatest numbers. They do not remain larvae or prepupae, but during the course of the winter usually transform into pupae, which emerge as adults in the spring. During late November, December and early January 1931–1932, 291 full-grown larvae were placed in the insectary for observation. Thirty-three per cent of this number produced adults; twenty-five per cent of the total worms under observation were living adults from April 25 to May 3.

Experiments with the pupae indicate that they can withstand relatively low temperatures, but they emerge in such large numbers during warm

spells that the chances of winter survival through individuals entering the winter as pupae is not nearly so favorable as from those entering as full-grown larvae. Two hundred and twenty-five pupae placed under observation in November 1931 did not produce a single adult as late as April 1932. Seventy-five pupae collected on December 23, 1931, produced only 1.3 per cent living adults during the period of April 25 to May 3, 1932. The total percentage emerging during the winter was 30.6. Winter activity of individuals placed under observation on December 23, 1931, may be illustrated by quoting data from one record. "Seventy-five pupae collected at random and placed in open insectary December 23. January 21, living adults and many eggs present. February 16, living adults and eggs. February 26, living adults and eggs. March 6, living adults and eggs. April 14, eggs that were present on January 21 hatching. April 25, one living adult. May 3, one living adult. Total adults emerging 23."

Underhill recorded individual adults as living 53 to 65 days during the fall and winter months in Virginia. The writer has records of individual moths that lived 30 to 40 days during the months of December, January and February and then laid eggs which in turn hatched. The writer, from his experience, does not believe it is possible for adults to live through the dormant season. Several records are available where under open insectary conditions first stage larvae hatched during the period April 1 to 15 from eggs laid by adults that emerged and laid eggs in January. These adults emerged from individuals that entered the winter as pupae. Frequently adults emerging during January have been observed to lay eggs that hatch in April. Due to the improbabilities of such larvae reaching food either as growing potato vines or stored tubers, it is not believed that this succession is likely to be a factor in the establishment of the insect in the spring.

Experiments indicate that the death rate of the different stages of the tuber worm under some conditions as encountered in cold storage is greater than under conditions of fluctuating temperatures. All eggs and adults placed in storage at a temperature of from 35° to 40° F. were dead after a period of four months. Individual full-grown larvae and pupae were able to survive exposures of five months. Out of a total of 25 larvae and 125 pupae, the percentage producing adults was 16 per cent for the larvae and 1.6 per cent for the pupae.

It may be that storage at higher temperatures would be less fatal. In a number of experiments sixty to seventy per cent of the pupae held at a temperature of from 40° to 48° F. emerged after an exposure of 60 days.

The writer is of the opinion that for the potato tuber worm to winter successfully in Maryland under field conditions the stages involved must be located in well protected and shaded locations. This opinion is based on the fact that under open field conditions where full exposure to the sun occurs the temperatures above the threshold of development that accumulate from time to time is sufficient to cause all stages to emerge early in the winter. Frequently the temperatures in open fields on sunny exposures are 25° F. or more higher than those in protected or shaded localities.

RESULTS OF TWO YEARS' WORK WITH AN ATTRACTIVE SPRAY FOR CORN EAR WORM MOTH (*HELIOTHIS OBSOLETA* FAB.)*

By ROBERT C. BURDETTE, *Associate Entomologist, New Jersey Agricultural Experiment Station*

During the season of 1931, it was found by the writer that the moths of the corn ear worm could be attracted by the use of syrline, an invert sugar syrup.[1] This material was used at the rate of 8 pounds to 50 gallons of water and applied by means of a sprayer on the corn foliage. During this preliminary work various materials, such as lead arsenate, zinc arsenite, sodium arsenite, arsenious acid, acetone extract of derris, alcoholic extract of pyrethrum, nicotine sulfate and potassium cyanide were used in order to see if any kill of the moths were possible. None of these materials was effective in producing kill. The extracts of derris and pyrethrum, nicotine sulfate and potassium cyanide were repellent.

While discussing this problem with Mr. W. H. White of the Bureau of Entomology during the winter of 1931–32, he suggested the use of tartar emetic (potassium antimony tartrate) with the syrline spray. Tartar emetic was then being tested for the control of the tobacco horn worm moth.[2]

SEASON OF 1932.—During the season of 1932, tartar emetic was used with the syrline spray and it was found that the moths would feed on the material very readily. Experiments were set up to find the amount of tartar emetic necessary to give kill of the moths. From this set of experiments it was found that 1½ to 2 pounds of tartar emetic to 50 gallons of spray was necessary to give good kill. Dosages less than this gave

*Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

[1]Burdette, Journ. Econ. Ent., Vol. 25, No. 2, pp. 343–347.

[2]Gilmore and Milan, Journ. Econ. Ent., Vol. 26, No. 1, pp. 227–233.

poorer kill and doses greater than 3½ pounds caused a diarrhoeal condition in the moths and kill was decidedly reduced. While running the toxicity experiments it was noted that moths which had fed on the poisoned spray did not deposit eggs in the cages, while moths that fed on water alone laid a large number of eggs.

Several small blocks of sweet corn were sprayed each evening just after sundown during the period of silking but the infestation of wormy ears was not reduced. Several times during the period while spraying was being done dead moths were found in the corn field. These blocks were all sprayed during the period of second brood moths. In these small blocks only the outside row was covered with the poison spray with a hand sprayer. Examination one-half hour after spraying showed moths rather numerous on the sprayed rows. Rows sprayed with the same material through the middle of the blocks showed only very few moths. Observations showed that most of the moths were not in the blocks during the day but rested on the outside of the corn fields and as soon as dusk approached began flying back to the corn.

From the observations and results obtained from these small blocks, it was thought that the covering of larger areas around the edges of corn fields would give greater attraction to the moths and would result in a larger kill of moths.

A farm in the northern part of the state was found which was located 3 miles from the nearest corn fields. Work on this place began the 16th of August. A barrel pump was used with an orchard spray gun so that the spray could be thrown from 10 to 12 rows deep in the fields.

A truck was used for going around the fields. The method of applying the material to the outside rows of the corn field is relatively simple and can be done in a very short period of time. The spraying began just as the sun was going below the horizon and was stopped usually as soon as lights were needed on the truck. The speed of the truck determined the amount of spray applied to the corn. In these experiments the speed was so regulated that approximately 2 gallons of spray were applied to one acre. Each block had a band of the spray ten to twelve rows deep around the outside border. Within one-half hour or less after spraying moths could be seen flying to the blocks of corn and alighting on the sprayed foliage and beginning to feed. It was also found that moth flight was stopped during periods when the wind exceeded 12 miles per hour. Low humidities greatly speeded up the rate of evaporation so that the spray droplets would be entirely gone after about one hour. In high humidity periods the spray droplets would remain all night. There was generally very little feeding after the spray had been on about one

and one-half hours. As soon as the moths fed they would fly around looking for ovipositing places.

Observations and counts showed after the first few sprayings that very few moths were present in the fields. This was due to the fact that the spraying was being done between the second and third broods.

A two-acre block of corn started silking about September 2nd. The first spray was applied to this block on August 30th. This block was sprayed every night for the next eleven days. A few moths were noticed each evening after spraying. On September 3rd, the 4th, 5th and 6th rows on the east and west sides of the field were gone over carefully for dead and alive moths. Twenty moths were found, 15 of which were dead. On September 4th the same rows were checked over. Thirty-three dead moths were found with 7 moths alive. On September 5th 84 dead and 5 live moths were found. On September 6th 140 dead and 5 live moths were found. On September 7th 88 dead moths were found. September 8th showed 62 dead moths, September 9th 10 dead moths and September 10th 16 dead moths. For the period from September 3rd to September 10th on six rows through this field 447 dead moths were found. The males and females were about equal in number. It was also noticed that the side from which the wind was blowing always had a larger number of moths than the opposite side of the field.

A record of silk infestation with eggs in this field was made during the period of spraying. A check of silks with eggs present on September 6th showed only 40 per cent of the silks without eggs. September 8th the silks were only 25 per cent free of eggs with an increase of egg-free silks to 50 per cent on September 8th and 58 per cent on September 12th. This field of corn was not marketed as the corn failed to mature because of dry weather and what few ears did develop were entirely infested with worms. The corn in this block was very retarded and gave the worms every chance to develop to their greatest extent.

It was felt that the reason for the failure to get any reduction in this block was due to the large number of moths present and that any amount of spraying would not cut the population sufficiently to show a reduction of ear infestation. The kill would almost have to be entirely complete to give protection because only a few moths failing to feed would lay a sufficient number of eggs to infest the field. A check-up of the moths in the field during the period of spraying showed that from 85 to 90 per cent of the moths feed on the material sprayed in the field. Another possibility offered itself in that the rate of kill was not fast enough to give a kill before egg laying. This point was not checked during the 1932 season.

SEASON OF 1933.—The work began on the same farm as in 1932 on July 4th. This was just after the first brood had gone. No attempt was made to kill off the first brood of moths because of other work being done which interfered with the starting of the work earlier.

It was decided that regular spraying during the summer would reduce the number of moths so that a reduction in infestation would be noted by the third brood period. The same equipment was used during this season as during the previous season. After the first sprays were put on, very few moths were found over the corn fields and a check of the fields at the time of marketing showed less than a 10 per cent infestation of the ears due to the first brood and all of the blocks that silked during the period between broods were very slightly infested.

The second brood of moths began emerging during the last week of July and first week of August. The blocks that were in silk and all blocks that were two feet or more in height were sprayed around. These blocks were No. 9 which received 23 applications, No. 10 which received 19 sprays, No. 11 which received 13 sprays and No. 12 which received 11 sprays. These were the important blocks since they were the ones that would receive the brunt of the egg laying of the second brood because of their being in the stage most attractive to the egg-laying moths.

A check up of these blocks at picking time showed block 9 to be 32 per cent clean, block 10 to be 3 per cent clean, block 11 to be 11 per cent clean and block 12 to be 20 per cent clean. This was the order in which the blocks were picked. The infestation of the ears was not materially reduced by the use of the poison bait sprays. Another block on the far side of the farm which received no sprays was used as a check. This block may be compared with block 9 for variety and time of silking. This block at picking time showed 30 per cent clean ears. The reason for the smaller number of applications to blocks 11 and 12 was due to a heavy northeast storm which stopped work at this place as we were not able to get around the fields with the truck.

While the second brood moths were in flight a careful study was made of the moths after feeding on the poison spray. A water soluble black dye was used in the spray throughout the tests so that when the moths had fed the material could be easily seen in the stomachs. A check up of moths captured during the evening after spraying showed that 80 to 90 per cent of all moths had fed on the poison spray. A check up of all dead moths found in the field during the day showed all to have the poison present in the stomachs. It was seen that the moths were feeding but egg-laying was not stopped. Careful observations of egg-laying in the field were also made to see if the moths were laying eggs after feeding.

The work of 1932 in cages showed that the moths did not lay eggs after feeding on the tartar emetic spray. This was found not to be the case under field conditions. The moths were attracted to the spray, fed upon it and then went on through the field laying eggs until the poison took effect. The kill of moths was large but egg-laying was not prevented. The failure of the poison spray can then be attributed to the slowness of the poison used in the attractive spray bait. It is thought that the syrline spray is sufficiently attractive so that from 85 to 90 per cent of the moths would feed but that a new and more effective or rather a faster acting poison must be substituted for the tartar emetic in the spray. As yet no poison seems to carry this fast action on moths that would cut down the egg-laying.

This method of treating the corn field for the destruction of the corn ear worm moths seems to offer the best solution for the problem. The amount of material on an acre basis is low for the season. The method of applying the material is simple and certainly seems to give results as far as feeding of the moths is concerned.

All other methods that have been used looking toward a control of this insect have certainly not given satisfactory results. The work ahead for this problem as the writer sees it is the finding of a more adequate poison for the moth which is faster in its action or some material which will prevent egg-laying soon after feeding.

This method of attack is brought forward with the idea that other workers on the corn ear worm will have some suggestions or ideas that may help in the solution of the problem.

THE HISTOPATHOLOGY OF NERVE LESIONS CAUSED BY INSECTICIDES

By ALBERT HARTZELL, *Yonkers, N. Y.*

(Withdrawn for publication elsewhere)

EXPERIENCES WITH THE CODLING MOTH IN NEW YORK DURING 1933[1]

By P. J. Parrott, *Geneva, N. Y.*

Serious as was the injury by this insect (*Carpocapsa pomonella*) last year, the pest was more destructive and proved much more difficult to control in certain areas during 1933. In the apple belt extending from Rochester to the Niagara River the damage was alarming in its extent, and deep concern as to the future activity of the insect exists among many growers. In explanation of the unprecedented destructiveness of the pest several factors suggest themselves, chief of which is probably the temperatures during June and July which were higher than the average. The extremely hot weather during these months caused an early emergence of the entire first brood of moths, shortened the incubation period of the eggs, and stimulated the early maturity of the first brood of worms as well as the early development of the second brood of moths. This generation of moths was unusually large because of the rapid development and early maturity of the first brood of worms. The prevalence of high temperatures was conducive to maximum egg-laying thruout the entire summer, with resultant heavy oviposition.

The moths began to emerge on May 24, which date is seven days earlier than last year, and the peak point of emergence was reached in fifteen days. The date as to the first flying of moths is the earliest on our records, and the period during which the bulk of the moths emerged is the shortest as well as the earliest noted during the past eight years. During seasons of light infestation the period required for the moths to reach the peak point of emergence required normally from thirty to thirty-six days and, generally speaking, the moths do not start to fly until about June 1. This difference in the behavior of the insect during the past two years, characterized by drought and temperatures above the average as compared with its activities during seasons when conditions with respect to rainfall and heat are more normal, shows the importance of weather as a factor in determining the relative abundance of the pest from season to season. In this connection it is well to point out that the past two winters have been relatively mild and presumably there has not been the usual mortality of overwintering caterpillars due to sudden and severe drops in temperature. Then again, during the past year *Ascogaster carpocapsae* was much less abundant than during the preceding two

[1]Approved by the Director of the New York State Agricultural Experiment Station for publication as Journal Paper No. 25. Dec. 23, 1933.

seasons, the average rate of parasitism in unsprayed orchards being as follows: 1931, 14.56 per cent; 1932, 8.07; 1933, 6.45. With respect to *Trichogramma minutum*, parasitism of the eggs of the codling moth was noticeable in most orchards, but this species, generally speaking, did not appear to be as numerous or as effective as during previous years.

Coincidental with the period of heavy infestation there has been a disposition on the part of many growers to omit important spray applications because of the need of economy or in order to avoid complications with spray residue and spray-burn of fruit and foliage. The substitution of calcium arsenate for lead arsenate led to unfortunate experiences in a number of instances. While perhaps of less importance than the weather, such practices have undoubtedly contributed to the building up of the rate of infestation and probably explain the disappointments of some growers in their attempts to combat the pest.

INJURY IN DIFFERENT FRUIT DISTRICTS OF THE STATE.—As during other seasons, the amount of injury caused by the codling moth varied in extent in the more important apple-growing sections of the State. In the Champlain Valley the infestation ranged from two to nine per cent in plantings that were thoroly or fairly well sprayed and which received three or four cover applications. In some instances severe injury was observed in the immediate vicinity of packing houses, the rate of infestation varying from 15 to 60 per cent, altho the major portion of the plantings usually exhibited a high degree of freedom from injury. On an average untreated orchards sustained a loss of about 25 per cent of the crop thru worm-holes and stings.

In the Hudson Valley the opinion prevails generally among most growers that injuries were more important than last year. Well sprayed orchards on an average showed 1 to 8 per cent injury for worm-holes and stings at the time of harvesting the crop. In unsprayed orchards approximately 30 per cent of the fruit revealed worm-holes and stings. While this general area showed a larger degree of freedom from damage as compared with other sections of the state, it should be stated that there were individual growers who were surprised at the extent of damage that they had sustained. In view of the efforts to spray along orthodox lines, anomalous as it may seem, dissatisfaction with the season's results was no more marked than in the case of a few operators of large commercial plantings, involving in some instances fairly large blocks of old trees. In such plantings from 30 to 40 per cent of the apples displayed stings and worm-holes.

As previously noted, the codling moth caused serious injury thruout western New York. The bulk of the damage was produced by the second

brood and developed during August and September; in fact, injury continued up to the time that such varieties as McIntosh, Greening, and King were being picked, and it had not entirely ceased when Baldwin and other late sorts were harvested.

Injury varied greatly in degree, according to variety and location of orchard. In general, King, Twenty Ounce, McIntosh, Alexander, Wolf River, and large and fast growing sorts were more seriously damaged than such varieties as Baldwin, Greening, Russet, Ben Davis, and Delicious.

In Niagara county the injury was, generally speaking, more serious than any other area. Along the Niagara frontier many orchards of the more susceptible varieties were severely damaged even tho the trees were well sprayed and had received five cover sprays with a lead arsenate content of 3 pounds per 100 gallons of mixture. The injury varied from 35 to 75 per cent, a surprisingly large number of the fruits displaying worm-holes. Where the same number of cover sprays were made with a lead arsenate content of 5 pounds about 90 per cent of the fruit was harvested free of stings and worm-holes. Poorly sprayed or untreated orchards, irrespective of varieties grown, were practically a complete loss, infestation of fruit ranging from 90 to 100 per cent. In this connection it may be of interest to note that in order to study the seasonal activities of the pest weekly thinnings were made of a number of unsprayed trees to remove all fruits which showed fresh entries by the caterpillars. So continuous and severe was the infestation of the apples by the worms that at the time of harvesting no fruits were left on some of the trees. With the less susceptible varieties of such sorts as Greening, Baldwin, Ben Davis, etc., which represent the bulk of the apple crop and which received on an average of from three to four cover sprays with a lead arsenate content of 3 pounds per 100 gallons, evidence of infestation was generally less than the foregoing figures, injured fruit ranging from 25 to 50 per cent of the crop, altho there were occasional orchards which presented very satisfactory conditions.

In orchards bordering on Lake Ontario less difficulty was experienced in combating the pest. As a rule the orchards that received three cover sprays using lead arsenate at the rate of 3 pounds per 100 gallons displayed injuries not to exceed from 10 to 20 per cent of the crop.

Altho the situation in Orleans and Monroe counties was not, generally speaking, as critical as in certain areas of Niagara county, most orchards suffered severe injury. In marked contrast to adjacent plantings, here and there orchards were observed that displayed a nominal amount of damage. In Wayne and Ontario counties infestation was in the main

noticeably higher than during the preceding year. In general, instances of intensive damage were less frequent than in those sections just mentioned; altho the leading growers as a rule are apprehensive as to future developments.

SUMMARY OF EXPERIMENTAL EFFORTS.—In view of the developments with respect to the codling moth, particularly in Niagara county, the primary considerations of the experimental efforts this season were: (1) To determine the relative efficiency and safety of new insecticides in comparison with standard materials; (2) to make chemical analyses of spray residue; and (3) to ascertain the effectiveness of the washing process in removing spray deposits. The results of these efforts are briefly summarized as follows:

Fifty-two experiments were conducted with twelve of the most promising insecticides. These were lead arsenate, calcium arsenate, copper arsenite, zinc arsenate, magnesium arsenate, manganese arsenate (manganar), nicotine tannate, cupran, anabasine, cryolite, Ku-ba-tox, and nicotine. Of this list, three proved superior to all others in effectiveness as follows: (1) Lead arsenate alone or with oil, (2) nicotine and oil, and (3) manganese arsenate alone or with oil. While nicotine with oil and manganese arsenate possess useful properties, their field of usefulness is restricted. Lead arsenate proved the best single insecticide considering efficiency, economy, safety to the trees, and compatibility with other spray materials. Its chief defect is that if it is not used with heavy dosages and frequently enough stings occur on the fruits. If used in amounts necessary to prevent stings difficulties are encountered with spray residues and these are objectionable with respect to both the lead and arsenical content. Moreover, four or five cover sprays with large arsenical dosages frequently result in spray deposits that may exceed tolerance limits by eight or ten times. Where such excessive amounts exist it is not always certain that a single treatment by a cleaning process will reduce the spray deposits below later spray limits. The problems with respect to the prevention of stings and spray residue have developed to their present stage of importance as a result of the hot and long growing seasons during the past four years, and they are of grave concern only to the apple industry of western New York. As far as this particular area is concerned, as long as meteorological and other conditions continue exceptionally favorable for the codling moth there seems to be no satisfactory solution of these two difficulties in sight. Admittedly, with no efficient substitute for lead arsenate, the situation with respect to spray practices is at present unsatisfactory considered from the standpoint of either the fruit grower or spray specialist. Much will depend

on the weather. If conditions in this respect are more normal it is presumed that the difficulties associated with the control of the pest and removal of spray residue will be less acute.

With respect to the Champlain Valley and Hudson Valley, the customary treatments with lead arsenate in lime-sulfur or in one of the milder sulfur fungicides have, on the whole, afforded satisfactory control of the codling moth. Moreover, the spray program that is being followed has not so far led to difficulty with spray residue.

CODLING MOTH CONTROL EXPERIMENTS DURING 1933

By S. W. HARMAN, *Geneva, N. Y.*

The Western New York Fruit Belt experiences greater losses from the codling moth (*Carpocapsa pomonella*) than any other section of the state. Previous to the past few years the control of this pest was not especially difficult, requiring from two to four summer spray applications of lead arsenate, using from 2½ to 3 pounds to 100 gallons. With the recent increase in destructiveness of the pest common to other sections of the country, the problem of control has now reached the point where the investigator is taxed to the limit to prescribe a spray program which is effective against the pest and which meets specifications with respect to spray deposits. During the average season one full brood and a small percentage of a second brood is the usual condition in western New York. However, during 1933 exceptionally favorable conditions for the development of the insect resulted in maximum egg-laying thruout the summer and an unusually large second brood. Fully four-fifths of the injury to the crop was caused by the second-brood larvae.

Experiments conducted in this heavily infested district during the past season were to determine the relative efficiency and safety of new insecticides in comparison with standard materials, the amount of spray residue deposited on the fruit, and the efficiency of washing in removing the residue.

Control experiments were conducted in three different orchards embracing four varieties of apples; namely, King, McIntosh, Greening, and Baldwin. It was apparent from these tests that the relative susceptibility of the varieties to codling moth injury was in the order mentioned, King being most subject to attack. The infestations in the first three orchards were sufficient to produce 100 per cent wormy fruit when the summer or cover sprays were omitted. Materials that gave the best control with

five summer applications are as follows, the amounts mentioned being used in 100 gallons of water.

1. Lead arsenate 6 pounds.
2. Lead arsenate 3 pounds in the first codling moth spray, followed by 3 quarts of summer oil and 1 pint of nicotine sulfate in the next four applications.
3. Lead arsenate 3 pounds in the first codling moth spray followed by lead arsenate 2 pounds and 3 quarts of summer oil in the next four applications.
4. Manganese arsenate (Manganar) 4 pounds with 1 quart of summer oil.
5. Lead arsenate 3 pounds.

The straight lead arsenate treatments were the most satisfactory from the standpoint of appearance of the fruit, and the stronger dosage gave greater freedom from stings. Four applications of the oil-lead arsenate spray apparently was excessive treatment as fruit that received such a schedule was deficient in color and showed traces of russeting in the calyx cavity. The manganese arsenate plats were about equal in regard to control to those sprayed with 3 pounds of lead arsenate, however, the trees lost considerable foliage late in the season and the leaves remaining generally displayed marginal burning.

On McIntosh five summer applications of lead arsenate at the rate of 6 pounds in 100 gallons gave 89 per cent clean fruit; that is, 10 per cent stings and 1 per cent worms. The oil-lead arsenate treatment (3 quarts summer oil and 2 pounds lead arsenate) gave 80 per cent clean fruit; that is, 12 per cent stings and 8 per cent wormy, while 3 pounds of lead arsenate in the first two cover sprays and 2 pounds in each of the remaining three applications resulted in only 42 per cent clean fruit, 37 per cent stings, and 20 per cent wormy. These are examples of conditions existing in the most seriously infested orchards in the state. In an adjoining Baldwin orchard where untreated trees produced 71 per cent wormy fruit, four codling moth sprays using 3, 3, and 2, 2 pounds of lead arsenate in 100 gallons respectively produced 90 per cent clean fruit, the injury being stings.

The variety King was selected for the comparative tests of the various new and promising materials because of its susceptibility to codling moth attack. This large growing apple requires more frequent spraying as compared with McIntosh, Greening, and Baldwin for equal protection, and with the five summer applications the comparative values of the different sprays were very apparent. The total crop including the dropped fruit from at least two trees in each plat furnished the data given in the table. If the drops were excluded the rate of efficiency would be

noticeably higher. The injury is expressed in the table in the terms of stings and worm holes, fruit displaying both stings and worm holes being classed as wormy.

The data express the control obtained with five cover sprays on King apples in one of the most serious infestations in the state. Figures show the standard 3-pound dosage of lead arsenate to be insufficient to effectively combat such an infestation. Lead arsenate, manganese arsenate (Manganar) and nicotine-oil appear to be the most effective materials. The other treatments including magnesium arsenate, calcium arsenate, copper arsenite, zinc arsenate, cuprous cyanide (Cupran), cryolite, nicotine tannate, anabasine-oil, and derris extract (Ku-Ba-Tox), all show high percentages of wormy fruit.

No spray injury developed in these test plats other than that already mentioned, with the exception of calcium arsenate. This arseniçal when used with bordeaux on Greenings caused considerable yellow leaf and dropping of the foliage.

COMPARATIVE VALUES OF VARIOUS INSECTICIDES FOR CODLING MOTH CONTROL IN A BADLY INFESTED KING ORCHARD—1933

Treatment[1]	Per cent stings	Per cent worms	Per cent total injury
Lead arsenate 3 lbs.	60	13	73
Manganese arsenate (Manganar) 4 lbs.	63	21	84
Manganese arsenate 4 lbs. + 1 qt. oil	56	8	64
Magnesium arsenate 4 lbs.	4	82	86
Magnesium arsenate 4 lbs. + 1 qt. oil	10	83	93
Calcium arsenate 4 lbs.	46	42	88
Copper arsenite 1 lb. + 1 qt. oil	35	55	90
Zinc arsenate 2½ lbs. (4 cover sprays only)	31	58	89
Cuprous cyanide (Cupran) 2 lbs.	7	80	87
Cryolite synthetic 4 lbs.	16	66	82
Cryolite synthetic 4 lbs. + 1 qt. oil	24	52	76
Cryolite natural 4 lbs.	12	73	85
Cryolite natural 4 lbs. + 1 qt. oil	22	46	68
Nicotine tannate { 3 pts. tannin extract No. 50 / 1 pt. blackleaf 50	7	82	89
Nicotine tannate + 1 qt. oil	25	50	75
Nicotine-oil { First cover—lead arsenate 3 lbs. / Remaining sprays—nicotine sulfate 1 pt., oil 3 qts.	29	14	43
Anabasine-oil { First cover—lead arsenate 3 lbs., / remaining sprays—anabasine sulfate 1 pt., oil 3 qts.	19	50	69
Derris extract (Ku-Ba-Tox) 1 qt.	3	89	92
Derris extract (Ku-Ba-Tox) 1 qt. + 1 qt. oil	3	87	90
Check—no treatment	0	99	99

[1]The treatment for codling moth consisted of five cover sprays. The amounts given are for 100 gallons of spray.

Chemical analyses[1] were made of fruit from the different plats to determine the amount of spray residue remaining on the apples. In general all of the arsenicals left deposits in excess of the tolerance requirements. The fruit was washed in a one per cent hydrochloric acid solution at 59° F. in a Bean brush type washer within a period of two weeks after picking. The fruit was exposed to the acid bath in this washer for a period of from 25 to 30 seconds. The treatment effectively reduced the residue to meet requirements with the exception of Manganar, magnesium arsenate, and lead arsenate.

As a result of the washing tests it appears that during the past season for moderate infestations of the codling moth requiring not more than four cover sprays of 3 pounds of lead arsenate and applied not later than the first week of August, the fruit was effectively cleaned shortly after picking with a one per cent hydrochloric acid bath in the above mentioned machine. In more seriously infested plantings requiring sprays containing double strength lead arsenate, lead arsenate and summer oil or additional late season applications, the one per cent acid bath was not always equal to the task. Washing experiments are being continued with stronger acid and heated solutions to determine the requirements for properly cleaning fruit under the last mentioned conditions.

THE PROBLEM OF CODLING MOTH CONTROL IN DELAWARE

By L. A. STEARNS, *Entomologist, Agricultural Experiment Station, Newark, Delaware*

Apple-growers and entomologists alike have been forced, of late, to look upon the Codling Moth (*Carpocapsa pomonella*) with an increased respect for its capability to effect extensive damage. At the time of the harvest of the 1930 crop, when excessively high losses were experienced the feeling generally verged on hysteria. Orchardists lost faith in developed methods of spraying procedure and in the efficacy of lead arsenate for codling moth control. With infestation still at a substantially higher level than at any time prior to 1930, the necessity of removing spray residue has further complicated the situation. Experience in Delaware, during the past four years, emphasizes the fact that the problem of codling moth control in its essential features is unchanged. It is still a question of effective spraying procedure and

[1]Credit is due to G. W. Pearce, Division of Chemistry of this Station, for the residue analyses.

efficient orchard management, the concern primarily of the individual grower and his respective orchard.

In New Castle, the most northern of the three Delaware counties, the codling moth has never been an important factor to contend with in the production of a clean crop of apples. For the most part, the orchards in this County are old, comparatively small and scattered. Insofar as the seasonal life history of the insect is concerned, it is a typical two-generation area, with both broods moderately small in size. Even under the more exacting conditions of recent years, adherence to a spraying program of but two cover sprays for the first brood and one for the second has invariably resulted in the production of a crop of apples 98 per cent free from codling moth injury. Growers in New Castle County have found it unnecessary to resort to supplementary practices to insure adequate control of this insect.

Travel southward, 40 miles into Kent County in the center of the State and an additional 40 miles into Sussex, the southern-most county in Delaware and the situation is entirely different. Here the orchards are both old and young, large and in close proximity with each other. Many varieties are represented. This is a typical two and one-half generation area, with the first and second broods of considerable proportions and the partial third brood varying in size with climatic fluctuations from year to year. In many of the orchards of these two counties, adequate control of the codling moth is at present impossible except by adherence to a spraying program of three cover sprays for the first brood and one for the second, and furthermore, by recourse to supplementary control practices.

Conditions influencing codling moth infestation are much alike the country over. Certain aspects of the situation in Delaware, just presented, are worthy, therefore, of especial mention because of their somewhat universal application. The first of these is a matter of orchard management. In central and southern Delaware in contrast with the northern section of the State, many of the orchards are so large and the farming interests of the owner have become so varied that he is unable to devote the necessary attention to the details involved in effective spraying procedure. The responsibility for thoroughness in application has been delegated, in many cases, to low-paid and uninterested white or colored labor. In orchards, in which the owner himself or equally reliable members of his family are not concerned personally with the actual job of spraying or in which a sufficient wage differential has not been established for thorough spraying by the hired help, infestation is almost certain to increase.

The second point, which should be stressed, is the effect of orchard density. Intensive planting has characterized the development of areas favorable for apple production. At the same time, it has aggravated codling moth infestation and complicated the control problem. In districts of high orchard density, such as the Dover-Camden area in Delaware, the expenditures of the individual grower in energy, in time and in money may be partly or largely nullified by inactivity on the part of his neighbors. Under these conditions, a substantial reduction in infestation can only result from organized and continued community effort.

Finally, it is a significant fact that, both in the case of the orchard district and in the individual orchard, there is an apparent, definite relation between conditions of infestation, during 1930, 1931, 1932 and 1933, and the population of codling moth previously existing therein.

The apple crop in Delaware ranks high among the agricultural products of the State. Shipments, during an average year, exceed a million bushels. The early-apple industry is highly developed, the returns from this business alone amounting to $750,000 annually. Delaware is the leading state in the production of Williams Red and only two states, Illinois and Tennessee, have larger plantings of Yellow Transparent. Approximately 36 per cent of its acreage is devoted to these two varieties and an additional 16 per cent to Stayman Winesap, by far the most important of the late apples locally.

With so high a percentage of the commercial crop in Delaware comprised of the three varieties mentioned, the initial move in 1931 toward more adequate protection from codling moth injury was a certain revision of the apple spray program. This action involved the insertion of an additional, third application for first brood control, an increase in the dosage of lead arsenate from 3 pounds to 4 pounds and the inclusion of fish oil at the rate of 1 pint per 100 gallons of spray. In the published program, these three, first brood, cover sprays were spaced at intervals, 10, 20 and 30 days subsequent to the petal fall application. Each year, however, developmental conditions have determined their most effective distribution and specific dates for application have been recommended through the "Spray Service." (Recommended dates of application in 1933—May 8, May 17, May 31 and June 12, respectively). This revision of the apple spray program served a dual purpose. It provided the important, early-apple crop with the increased protection needed and it concentrated control activities, insofar as spraying was concerned, upon first brood control, a most desirable feature from the standpoint of spray residue on late-

harvested fruit. No change was made in the case of the fourth cover spray of lead arsenate, applied annually at the close of the first week in July for early, second brood control. Recent experimental evidence suggests, however, the desirability of an optional recommendation, for more effective second brood control but with added expense to the grower, of a series of three nicotine-oil sprays to be applied in early July, late July and early August, respectively. (Dates of application in 1933—July 6, July 24 and August 7, respectively).

Aside from the revision of the apple spray program just considered, the practices recommended in Delaware for codling moth control during the past three years may be concisely stated as follows:

Scrape and band; store infested containers and keep packing houses tightly closed; destroy infested drop and cull fruit; and SPRAY—as never before—if necessary, removing excess residue at harvest.

Where community action has seemed necessary, effort has been so directed. In most cases, however, adherence to the control program has come as a result of personal visits to growers.

Although forced economy has resulted in some curtailment of control endeavors during the past year, the concerted effort of apple-growers in 1931, 1932 and 1933, has effected a substantial reduction in the high level of codling moth infestation, which prevailed rather generally throughout Kent and Sussex Counties in Delaware subsequent to the drought of 1930. Certain orchards, in which the fruit of that year was almost a total loss, produced a crop in 1933 over 90 per cent free from codling moth injury. On July 1 of this year, with the peak of first brood entry definitely past, injury was generally negligible. But for the disrupting influence upon the morale of the industry of announcements and counter-announcements on the point of tolerance and also for the widespread indecision in the minds of growers regarding spraying procedure resulting from a veritable flood of information, accurate and otherwise, concerning this, that and the other substitute for time-proven practices and materials, local crop conditions in 1933 might otherwise have been viewed in retrospect with more than a fair degree of satisfaction.

Insofar as Delaware is concerned, there are certain encouraging features of the present situation worthy of mention. Although here and there severe conditions of infestation still exist, there is evident a returning confidence that the codling moth can be controlled. Growers are now more inclined to view the question of control as an individual problem. They are studying anew the control difficulties peculiar to their own orchards and adapting general recommendations to their

particular needs. Where control has already been effected it has resulted thru recognition on the part of the grower of the conditions responsible for infestation and from his ability to make the necessary changes in spraying procedure and orchard management. The continuation of this effort and its eventual success will depend upon the ability of the industry to finance it.

CODLING MOTH CONDITIONS AND CONTROL IN WEST VIRGINIA

By EDWIN GOULD

The codling moth (*Carpocapsa pomonella*) is by far the most destructive insect affecting the apple crop in the Cumberland-Shenandoah fruit section of West Virginia. Its destructiveness does not fluctuate widely from season to season, as in the case of many other insects, but it is steadily becoming more serious each year. If the present rapid increase continues, this insect will soon be the limiting factor in the apple growing business, in fact, it is already the limiting factor in many large orchards.

The codling moth is not yet nearly as serious a pest in the mountainous section of the state where, in many orchards, its control is almost entirely ignored in the spray schedule. In the older and more densely planted valley sections, increasingly severe losses are occurring in spite of timely and thorough spray applications. In some of these valley orchards the present annual loss from codling moth is well over 50 per cent even when the apple crop is heavy. When it is light, the concentration of worms is so heavy that the fruit often cannot be packed and is worthless except for by-products.

The per cent of wormy fruits is always less in years of heavy crops but the actual money loss is much greater. During the light crop years, special attention should be given to codling moth control; the entire crop should be picked and destroyed early or else special attention should be given to controlling the pest by thorough spraying. Unless better control of codling moth is effected, it is apparent that with the present low apple prices and increasing cost of production, a large number of marginal orchards will have to be abandoned.

This notable increase in codling moth population in West Virginia orchards is due to many factors. Unusually favorable weather conditions during the past few years is one of the most important of these. The omission of second brood sprays due to the spray residue limita-

tions has also been a very important factor in the increase of the moth population. Under equipment, improper timing of spray applications and ineffective application of the spray are among the contributing factors to this increase in population. The common practice of discontinuing the spray program after a destructive hail and the problem of spraying interplanted orchards, especially where early and rapid growing varieties are interplanted with late ones, has no doubt also played a part in the increase in recent years. Finally, we have the problem of the abandoned orchards which act as breeding grounds and centers of spread for this destructive insect.

This serious situation together with the spray residue difficulties is stimulating vigorous research efforts and lends hope that cheap and more effective control measures will evolve in the near future. Spraying with arsenate of lead is still the most effective control measure now used. Of the many non-lead arsenicals and non-arsenicals, such as calcium arsenate, manganese arsenate, zinc arsenate, Paris green, copper cyanide, oils and nicotine sulphate, used singly and in various combinations in our experimental plots this year, none give promise as an immediate substitute for arsenate of lead.

The most important consideration in this critical situation is effective control by means of the first brood sprays. Obviously, if effective control is obtained in these sprays, the second brood sprays become less important and it has been the lack of control of the second brood that has aggravated the codling moth problem. In order to get effective worm control in the first brood sprays it has been found necessary to keep both fruits and foliage constantly covered with poison.

It is known that first brood sprays alone will not keep the codling moth under control, especially where dense populations of the insect occur. An additional first brood spray together with two or more second brood sprays will likely be added to our present schedule. Such a program of spray applications will necessitate washing the fruit to remove excess residue. The present spray applications give commercial control in inverse proportion to the codling moth population; the heavier the population the less effective the spray. Spraying usually gives temporary control where the codling moth population is small but where dense populations occur, supplementary measures must be used. In many orchards the codling moth population is so great that none of the present spray schedules give commercial control.

Our experimental work in 1933 included 36 different combinations of spray materials and arrangements in spray schedules. It is impossible to present all of the data resulting from these experiments at this time.

The following data, however, are representative of this large number of tests. The plots were located in a large orchard infested with a very dense population of codling moth. The check plots in this orchard showed 67.95 per cent wormy fruits. Plots receiving four first brood sprays of lead arsenate, at the rate of 3 lbs. per 100 gallons, showed 51.88 per cent wormy fruits. The fruits of this plot at harvest time had an arsenic residue of .0192 grains per pound. The addition of one second brood spray of arsenate of lead to the above plots actually seemed to result in an increase of wormy fruits, the percentage being 57.54, while the arsenic residue increased to .0268 grains per pound. Plots receiving four first brood sprays of calcium arsenate, at the rate of 3 lbs. per 100 gallons, showed 66.15 per cent wormy fruits and an arsenic residue of .0066 grains per pound of fruit at harvest time. The addition of one second brood calcium arsenate spray to the above plots reduced the wormy fruits to 57.04 per cent but the arsenic residue increased to .0142 grains per pound of fruit. Plots receiving a first brood treatment of three lead arsenate sprays and one calcium arsenate spray showed 60.01 per cent wormy fruits with an arsenic residue of .0132 grains per pound, while those receiving only two arsenate of lead sprays and two calcium arsenate sprays showed 62.13 per cent wormy fruits and an arsenic residue of .0103 grains per pound. The last plots mentioned above received our recommended spray treatment, for 1933 and it should be noted that the arsenic residue is just slightly above the tolerance. It is evident that none of the above treatments gave appreciable control yet the residue analyses indicate that the fruit was well covered with poison. It is noteworthy that none of the 36 different treatments in this orchard gave significant control, a fact which seems to indicate that present control measures are inadequate in orchards which have accumulated such dense populations of codling moth.

The adoption of such supplementary control measures as scraping the trees to remove all rough bark and the use of lethal bands has been found to be profitable. Orchard sanitation is very important in destroying hibernating quarters of the larva and adds to the effectiveness of bands. Thinning during years of heavy fruit set is a valuable practice; it not only removes wormy fruits but it breaks up the clusters in certain varieties, thus permitting a better application of spray material. It is very essential that all wormy fruits, either windfalls or thinnings, be destroyed or removed from the orchard. Heavy pruning opens the trees and affords a better opportunity for effective spraying, especially on the inside and in the top of the trees where the bulk of the carry-over worms are found. Packing house sanitation and the care of prop piles

as well as all other possible harbors should be given more consideration. The adoption of these control measures is increasing each year in West Virginia especially among growers who lack equipment to wash their fruit. Such growers have found these practices to be both practical and profitable.

CODLING MOTH IN PENNSYLVANIA*

By H. E. Hodgkiss, H. N. Worthley and D. E. Haley, *The Pennsylvania State College, State College, Pa.*

The distribution of codling moth (*Carpocapsa pomonella*) is statewide. The topography of Pennsylvania has a modifying effect on the nature of the infestations which renders the insect more virulent in the southcentral counties. In the higher levels where the season develops later the injuries are always lighter. In no section are apples immune and orchards poorly sprayed usually rank high in codling moth damage.

The broods of codling moth vary somewhat. There appears to be but a single complete brood and a small second brood of worms through most of the area north and west of a diagonal drawn from the northeastern corner to a mid-point on the southern boundary of the state. On a relief map this will coincide very closely with the coastal plain levels although it contains the Blue Mountain ridges. Local areas of heavy infestation occur on the higher levels and along the main water courses, notably in Erie County, Allegheny County, the lower Juniata Valley and the upper Susquehanna River to the confluence of its branches at Sunbury, Northumberland County. Throughout the higher levels in the Allegheny Mountains and west of State College the codling moth is a constant threat but control is fairly easy. In the upper half of the eastern coastal region there is a full first brood with a small second brood, and in the central and lower eastern half a full first brood and larger second. But in the lower reaches of the Susquehanna River and in the Cumberland Valley this second brood is still more nearly complete, and in some years a partial third brood has been suspected. Some of the difficulties with which we have to contend may be shown in a graph representing emergence and length of the periods of moth infestation. Attention is called to the variation in emergence of the wintering brood over the period 1925–1933. Also to the length of flight periods as indicated by the graph (Figure 5).

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Control operations are not difficult except in the area of extensive commercial orcharding. In the western and northern counties comprising more than one-half of the state four codling moth applications are

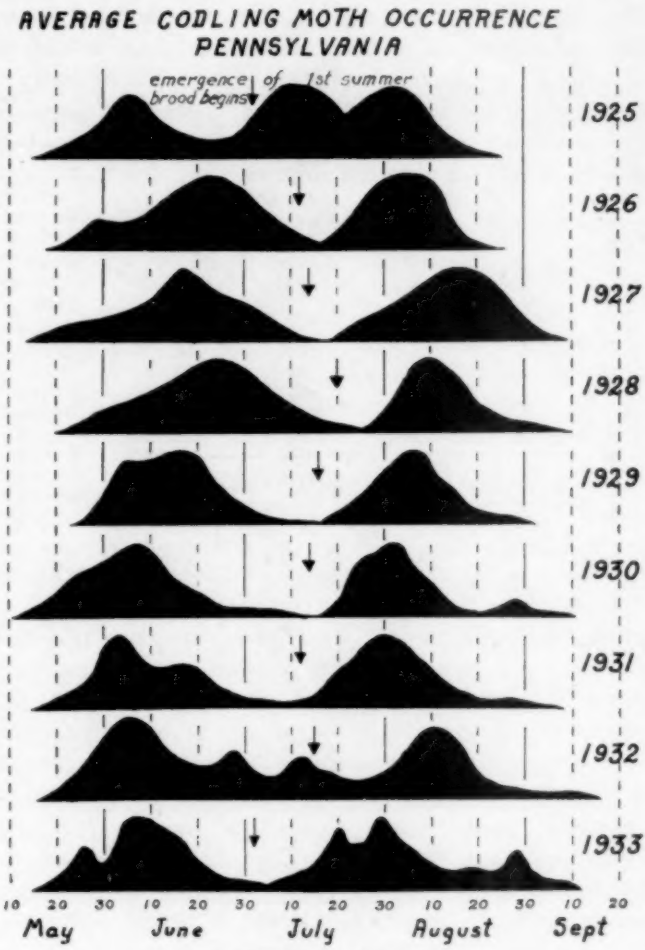

FIG. 5.—Codling moth occurence.

sufficient. These include the petal fall and three cover sprays. In isolated orchards through this area often two cover sprays are all that are made with a large proportion of clean apples resulting. In the coastal plain region five applications are sufficient. In the heavily infested area five are required except in cases where extra precautions have resulted

in a reduction of codling moth population to the extent that the last application in July can be omitted. Even in this region comprising portions of 4 counties the number of cover sprays needed often is an individual orchard consideration.

The effect of this program over a period of years is shown in the following tabulation, Table 1, of orchard surveys in 1,251 orchards in the 55 counties having spraying information. The incompletely sprayed orchards include those where the timing, method of applications or machinery employed prevented the harvesting of reasonable amounts of apples free from codling moth injuries.

TABLE 1. CODLING MOTH SUPPRESSION 1929–1933

Year	Method of operation	No. of orchards	Conditions with respect to apples		
			Total yield Bu.	Insect injury Total	Per cent
1929	Complete	114	522,883	12,549	2.4
1930	"	103	696,869	9,059	1.3
1931	"	96	677,575	17,617	2.6
1932	"	125	1,122,800	20,210	1.8
1933	"	149	1,033,900	38,828	2.6
1929	Incomplete	24	52,740	4,536	8.6
1930	"	94	342,910	36,691	10.7
1931	"	180	947,350	85,261	9.0
1932	"	217	1,054,330	95,628	9.07
1933	"	149	914,500	130,442	12.4

The condition with respect to spray residues has been given attention in the making of programs for codling moth control. Fortunately during most of the years that tolerances have been placed we have been able to follow a definite schedule of cover sprays using lead arsenate at the rate of 3 pounds to each 100 gallons of liquid and have not experienced serious trouble from that source. In all instances where apples have shown arsenic above the tolerance the cause can be directly traced either to the use of extra amounts of poison or to delays in applying the last cover spray.

ANALYSES OF SPRAY RESIDUES.—This phase of the work was done through the cooperation of the Department of Agricultural and Biological Chemistry under the direction of Dr. D. E. Haley. Some 475 samples of fruits have been collected at harvest over a period of five years using the method described in the previous publications of this series.[1] The fruits had not been handled and were analyzed for total arsenic and total lead. The procedure of the analyses was the same as described in the articles above mentioned with respect to the arsenic. The relation of the samples to the arsenical tolerance, dosage of the poison,

[1]Jour. Econ. Ent. 20: No. 4, pp. 607–614, 1927; ibid, 24: No. 1, pp. 83–87, 1931.

fruit cover sprays and weather conditions is given in Table 2. For convenience in comparison the tolerance used is .01 grains of arsenic per pound of fruit, irrespective of earlier tolerance specifications. This year only seven samples showed arsenic trioxide slightly above .005 grains per pound of apples and of these two were .006; one, .007; two, .008; and two, .009 grains.

TABLE 2. ANALYSES OF APPLES FOR RESIDUAL ARSENIC 1926–1933

Year	No. of samples	Cover sprays	Seasonal dosage	Weather conditions	Residue conditions Tolerance		
					Above	Equal	Below
		No.	Lbs.		No.	No.	No.
1926.....	24	3	9	excess rain	0	0	24
1926.....	12	4	12		0	0	12
1930.....	28	3	9	dry	7	0	21
1930.....	68	4	12		14	8	46
1931.....	15	3	9	dry	3	0	12
1931.....	65	4	12		8	2	55
1932.....	47	3	9	mod. dry	2	0	45
1932.....	88	4	12		8	0	80
1933.....	6	3	9	excess rain	0	0	6
1933.....	6	4	12		0	0	6
1933.....	44	3	7		0	0	44
1933.....	13	4	9		0	0	13

In 25 additional orchards in this year's series where two cover sprays were applied, using a dosage of 2½ pounds of lead arsenate and 2 pounds of powdered milk to each 100 gallons, the arsenic trioxide per pound of apples ranged between a trace and .002 grains per pound of apples. Three cover sprays were put on in seven orchards using either calcium arsenate at the rate of 3 pounds to each 100 gallons of dilute spray, or lead arsenate 2½ pounds plus calcium arsenate 3 pounds to each 100 gallons of spray. The combinations of lead arsenate and calcium arsenate were either two pounds of lead and one pound of calcium arsenate or one of calcium arsenate and two of lead arsenate. No appreciable differences were noted in the arsenic trioxide where the combinations were used and it was either a trace or .001 grains per pound of apples. The apples treated with calcium arsenate at the rate of three pounds to each 100 gallons of dilute spray showed only .002 grains of arsenic trioxide per pound of apples. Some 21 samples were taken from orchards where control was poor due to practices used and on these apples not more than .001 grain of arsenic trioxide was found.

The lead residues were analyzed this year according to a modification of the method of Lynch,[2] as used by Percival and Potter.[3] For

[2]Lynch, W. D., et al. Poisonous Metals on Sprayed Fruits and Vegetables. U. S. D. A. Bul. 1027, 1922. Percival, G. P. and Potter, G. F.

[3]Amount and Variability of Spray Residue on New Hampshire Baldwins. N. H. Tech. Bul. 49, 1932.

this purpose 58 samples were selected from the lots collected and these represent the average conditions in completely sprayed commercial orchards. Four of these samples when analyzed had a lead content in the residue above the tolerance of .02 grains of lead per pound of apples. The highest amount found was .03 grains per pound of fruits and the most of them were between .004 and .009. Only five of them ranged between .02 and .03 grains per pound of apples. There was no relation between the amounts of arsenic and the amounts of lead in the same sample. The larger amounts of lead were, however, from samples taken in either our demonstration orchard in Franklin County or in orchards where the fruit growers spray their trees according to the method we have demonstrated to them and use in our own operations.

EXPERIMENTAL DATA ON CODLING MOTH CONTROL.—The foregoing discussion is of general orchard conditions with especial reference to the effectiveness of the control program suggested through the Agricultural Extension Service.

A codling moth research program was initiated in 1928, but until 1931 the work was limited to a study of timing methods for spray applications[4] and the use of supplementary control methods, notably banding.[5] Bait pails appear to be more satisfactory than emergence cages in heavily infested orchards, because they indicate more clearly the periods of moth flight. During the past two years they have been used successfully in a number of commercial orchards. The scraping and banding of apple trees is rapidly becoming a general practice where the codling moth is a problem.

In 1931 spraying experiments conducted in a heavily infested Adams County orchard showed the necessity for four first brood cover sprays and the advisability of additional second brood sprays in such orchards. No undue residue of arsenic resulted from four cover sprays ending July 1. In 1932 the application of five cover sprays ending in mid-July reduced the codling moth population by half, but produced a residue of .028 grains of As_2O_3 per pound at picking time. Comparisons of spray combinations in 1932 indicated that the addition of casein or miscible oil would allow no reduction in the dosage of lead arsenate. A complete cover spray schedule of nicotine tannate with flotation sulphur was unpromising. However, fish oil at one quart per 100 gallons of spray increased the effectivenes of the standard spray mixture. It was not used in 1933 for two reasons. First, its nauseating odor when mixed with lime sulphur would force the use of a substitute

[4]Pa. Agr. Exp. Sta. Bul. 277, 1932.

[5]Jour. Ec. Ent. Vol. 25, No. 6, pp. 1133–1143, 1932.

fungicide not recommended by our pathologists. Second, it was feared that its marked adhesive properties would lead to danger of excessive residues of arsenic and lead, even if it were used in only one spray application.

The basis for this fear was a study of arsenical residues conducted at State College in 1932, which showed that both the arsenic and the degree of control were reduced by the addition of hydrated lime and increased by fish oil. Fruit given three cover sprays with hydrated lime fell under the tolerance, while two cover sprays containing fish oil fell above. In Table 3 are presented figures from a plot receiving lead arsenate at 3–100 in five cover sprays to show the effect of spray applications, growth of fruit, and weather conditions upon the amount of arsenic per unit of fruit surface. This treatment left .021 grains of arsenic trioxide per pound on the picked fruit.

TABLE 3. LOSS OF ARSENIC FROM NEW YORK APPLES AT STATE COLLEGE, PA., 1932*

	June 10* to June 20	June 21* to July 5	July 6* to July 24	July 25* to Aug. 4	Aug. 5* to Oct. 19
Ave. daily rainfall—inches	0.151	0.140	0.150	0.264	0.088
Surface area of fruit					
Per cent of total	8–17	17–28	28–44	44–54	54–100
Times increase during period	2.2	1.7	1.5	1.2	1.8
As_2O_3—*gms. per square meter of fruit surface*					
After spraying	1.058	1.275	1.034	1.148	1.590
Lost during period	0.686	1.072	0.770	0.548	1.467
Expected loss from growth	0.577	0.525	0.344	0.191	0.883
Per cent loss due to growth	84.1	49.0	44.7	34.8	60.2

*Spraying dates.

The "expected loss from growth" has been computed by dividing the amount of arsenic after spraying by the "times increase" in fruit surface during the period of loss, which gives the amount expected to remain if growth were the only factor concerned. The table brings out the following points.

1. During June, when the fruit was increasing rapidly in size, loss of arsenic per unit of surface was correspondingly high. The need of

[6]From unpublished thesis of W. S. Hodgkiss, Dept. of Agri. and Biol. Chemistry, The Pennsylvania State College.

accurate timing of spray applications to meet the peaks of egg hatching during this period was indicated even with intervals only 10 to 15 days between sprays.

2. If spraying stopped on June 21, when the fruit was only 17 per cent of its final size, subsequent growth would reduce the amount per unit area on the picked fruit to one-sixth the amount at the date of application. This fact was pointed out by Hamilton[7] whose studies indicated that the early cover sprays are not dangerous from the standpoint of arsenic tolerance.

3. As the season progressed and the fruit approached more closely its final size, less of the arsenic per unit area lost between spray applications was due to fruit growth. Thus by July 6 nearly 30 per cent of the fruit surface was present, and a third spray applied on this date produced .008 grains of As_2O_3 per pound at harvest. The table shows that where spraying was continued to August 5, when the fruit was over half grown, the arsenic on the picked fruit reached .021 grains per pound in this dry season, even though fruit growth accounted for 60 per cent of the loss during this period. It appears that in any year each spray application after the latter part of June will depend to a greater extent upon rainfall, which cannot be predicted to bring residues below the established tolerance at picking time. The recommendation of the U. S. Department of Agriculture in the spring of 1933 that lead arsenate be omitted after the second cover spray in our section was well founded, even though our 1933 experience indicated that three cover sprays at standard dosage would have been safe with the heavy August and September rains.

SUMMARIZATION.—Over most of Pennsylvania the small size of the second brood of codling moth larvae allows control to be obtained through a schedule of early sprays, without danger of excessive residues of lead or arsenic remaining on the picked fruit.

In the export apple growing region of southcentral Pennsylvania, the development of a large second brood of worms, and of a possible small third brood in favorable seasons, requires lead arsenate at standard dosage in three or four cover sprays extending to the middle or latter part of July. For the most part the necessary schedule has been applied without bringing arsenic above the tolerance.

In orchards where large populations of codling moth have been built up control constitutes a special problem. Often this relates to individual orchards. Four first brood cover sprays, additional second brood sprays,

[7] Jour. Ec. Ent. 22: No. 2, pp. 387–396, 1929.

and banding of trees are indicated. In the absence of substitutes for arsenic that can be recommended without qualification, our experimental studies indicate that adequate dosage and amounts of lead arsenate produce a danger of excessive residues after the latter part of June, and that fruit washing must be resorted to in heavily infested orchards in comparatively dry seasons.

The general orchard survey shows that a rather high amount of commercial control can be obtained under the present standard system without danger from an excess of either arsenic or lead residue. To obtain this efficiency the dosages used must be correct, the applications timely, coverage of leaves and fruits complete, and the spraying equipment must be sufficient to do the job correctly.

Insects and Airplanes.—In the syndicate cartoon "Believe It or Not," on December 14, 1933: the following was published under the picture of an airplane:

"INSECTS FORCED AN AIRPLANE TO LAND!"

"Salt water gnats,—sucked into the motor—so choked the air intake screen on the carburetor that the motor slowed down to 900 revolutions per minute. The pilot, Lt. R. A. Wilson, was forced to land. Ogden, Utah, 1933."

I inquired of the firm producing these cartoons for dates and received the following communication:

"ANTI-AIRCRAFT GNATS"

"On June 5, 1933, an army transport plane was forced down on a small island in Great Salt Lake, Utah, on account of water in the gas. Service mechanics from the Salt Lake airport were dispatched to the rescue, and the gas trouble remedied. However, salt water gnats are so plentiful in that vicinity that they were sucked into the air intake of the motor and into the screen of the carburetor. The ship flew as far as Ogden, when the motor slowed down to 900 revolutions and forced a landing.

This unique incident of aviation is recorded in the log of the pilot, R. A. Wilson, and in the records of the Airport Manager in Salt Lake." "Believe It or Not."

There is almost no doubt that the insect causing this trouble was *Ephydra gracilis* Packard. I published some notes about the great abundance of this fly in the Journal of the N. Y. Entomological Society, volume 20, 1912, page 78.

The fly has been accused of stopping railroad trains before.

J. M. ALDRICH, *Associate Curator of Insects, U. S. National Museum*

CODLING MOTH SPRAYING EXPERIMENTS IN PENNSYLVANIA IN 1933[1]

By H. N. WORTHLEY, *The Pennsylvania State College*

SEASONAL CONDITIONS.—Nineteen thirty-three was the fifth consecutive year showing conditions generally favorable for codling moth (*Carpocapsa pomonella*) development. Temperatures were again above normal, and exceeded 1932 from March through July. Rainfall was deficient in June, somewhat above normal in July and September, and two and one-half times normal in August. At Gettysburg in Adams County, 20.6 inches of rain fell from July through September, as against 7.9 inches in 1932.

Codling moths were trapped in bait pails from May 14 to September 11. The peaks of moth flight centered about May 22, June 3, June 12, June 19, and June 24 for the overwintered brood, and July 19 and August 2 for the first brood. An unusually heavy flight on August 26 gave indirect evidence of a partial second brood of moths. Larvae were first seen entering the fruit on May 28, and fresh entry was abundant by June 6. First brood larvae were leaving the fruit by June 15. First brood moths began to emerge July 2. Many small larvae were found in picked apples in mid-October.

METHODS.—Comparisons of arsenicals in various spray combinations for control of the first brood of worms, and of substitutes for arsenic in sprays for the second brood, were conducted in a block of 16-year

FIRST BROOD SPRAYS ON ROME, BIGLERVILLE, PA., 1933

	June 2	June 12	June 30	Total arsenical
Row 1	Lead arsenate, 2.5 lbs.	Lead arsenate, 2.5 lbs.	Lead arsenate, 2 lbs.	7 lbs.
Row 2	Calcium arsenate, 2.5 lbs.	Calcium arsenate, 3 lbs.	Calcium arsenate, 3 lbs.	8.5 lbs.
Row 3	Lead arsenate, 1 lb. Calcium arsenate, 2 lbs.	Lead arsenate, 1 lb. Calcium arsenate, 2 lbs.	Lead arsenate, 1 lb. Calcium arsenate, 2 lbs.	3 lbs. 6 lbs.
Row 4	Lead arsenate, 2.5 lbs. Skim milk powder, 2 lbs.	Lead arsenate, 2.5 lbs. Skim milk, 2 lbs. Nicotine sulphate, 1 pint	Lead arsenate, 2 lbs. Skim milk, 2 lbs.	7 lbs.
Row 5	Lead arsenate, 2.5 lbs.	Lead arsenate, 2 lbs. Fish oil, 1 qt.	Lead arsenate, 2 lbs.	6.5 lbs.
Row 6	Lead arsenate, 2.5 lbs. Hydrated lime, 1 lb.	Lead arsenate, 2.5 lbs. Hydrated lime, 1 lb.	Lead arsenate, 2 lbs. Hydrated lime, 1 lb.	7 lbs.

[1]Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station, November 18, 1933, as technical paper No. 617.

old Rome trees in the Heacock orchard at Biglerville in Adams County. The applications were made by the owner with a new Bean spray gun at 350–400 pounds pressure, from the ground. Each tree was completely sprayed before moving to the next and received approximately 8 gallons of material. Six count trees were selected in each treatment. All drops, thinnings and picked apples were scored for codling moth injury.

ARSENICALS.—The materials used in the schedule of first brood sprays are given on page 240 in amounts per 100 gallons of spray.

TABLE 1. ARSENICAL SPRAY MIXTURES FOR FIRST BROOD CODLING MOTH ROME ADAMS COUNTY

1933. 3 cover sprays, (1) June 2, (2) June 12, (3) June 30

Arsenical Kind	Total	Time of Counts	Apples counted	Clean apples	Wormy apples	Success attacks	Spray burned
			No.	%	%	%	%
1 Lead.....	7 lbs.	1st brood—July 12*	1295	85.8	3.0	18.3	0.7
		Total for season†	1680	19.5	46.9	33.9	2.8
2 Calcium.....	8.5 lbs.	1st brood—July 12	1325	87.1	2.5	18.9	5.9
		Total for season	2370	32.5	55.1	60.4	14.6
3 Lead.....	3 lbs.	1st brood—July 12	1109	87.4	1.7	12.5	7.6
Calcium.....	6 lbs.	Total for season	2602	36.3	42.0	46.8	19.9
4 Lead.....	7 lbs.	1st brood—July 12	920	86.5	1.4	9.0	1.6
+sk. milk and (2) nic....		Total for season	1535	34.9	37.1	36.8	2.1
5 Lead.....	6.5 lbs.	1st brood—July 12	1002	84.4	0.9	6.5	0.6
+(2) fish oil.		Total for season	1765	31.8	38.7	35.7	2.8
1932. 5 cover sprays, ending July 22							
Lead.....	15 lbs.	1st brood—July 8	200	92.0	0.0	0.0	
		Total for season	6202	84.3	3.5	18.3	

*Vertical sample on 6 trees—not picked.
†All fruit—thinnings, drops, picked—2 trees.

The calcium arsenate used was an "improved" brand new to the market. In row 10 the lead arsenate was a brand containing casein. Liquid lime sulphur was the fungicide used throughout, except for the application of June 12 to row 5, where flotation sulphur was used with the fish oil.

The abbreviated schedule and reduced amounts of arsenic were forced by the ruling on lead tolerance and the lack of washing equipment. Standard practise called for four sprays totaling twelve pounds of lead arsenate. The schedule as applied in 1933 totaled seven pounds in three cover sprays. The results of this effort are given in Table 2. For comparison, counts are included from the same block in 1932, in a plot which received lead arsenate at 3 pounds per 100 gallons in 5 cover sprays ending July 22.

The most striking fact in Table 1 is the inadequacy of the cover spray schedule and dosage of lead arsenate employed in 1933 in this heavily infested orchard. The short crop naturally resulted in a smaller proportion of sound apples. But in 1932 15 pounds of lead arsenate alone in 5 cover sprays produced 487 injured apples and 132 worms per tree, while in 1933 7 pounds of lead arsenate in 3 cover sprays produced 676 injured apples and 589 worms per tree. Thus under this treatment the codling moth population increased 446 per cent.

In the first brood counts of July 12 the treatments given rows 4 and 5 gave the best results. The small crop in row 6 made comparisons of doubtful value and the figures are not given in Table 1. Eight and five-tenths pounds of calcium arsenate in row 2 allowed more larvae to penetrate the fruit than 7 pounds of lead arsenate in row 1, its superiority in per cent sound and wormy fruit in the first brood counts being merely apparent, due to the larger crop. The mixture of lead and calcium arsenates in row 3 proved better than calcium arsenate alone in row 2. In both these treatments the calcium arsenate weathered rapidly from the fruit as shown by the high percentage of successful attacks at the end of the season and also by the smaller amounts of arsenic found on the picked fruit.

SPRAY INJURY.—Where calcium arsenate was used there was a large increase in the amount of arsenical injury. On the fruit this took the

TABLE 2. FOLIAGE INJURY FROM SPRAY COMBINATIONS, STATE COLLEGE, PA., 1933

3 cover sprays. June 1, June 15, June 28 with liquid lime sulphur, 2 gals. per 100. Counts Aug. 10. All leaves on 4 branches—2 trees

Materials per 100 gallons	Variety	Leaves counted	Leaves injured	Leaves dropped
		No.	%	%
Lead arsenate—3 lbs.	York	2274	1.8	1.4
	Stayman	1888	3.2	0.0
"Improved" calc. arsen.—3 lbs.	York	3144	30.6	18.4
	Stayman	1553	22.5	14.9
Standard calc. arsen.—3 lbs.	York	2404	16.7	8.1
Hydrated lime 3 lbs.	Stayman	1756	9.3	8.4
"Improved" calc. arsen.—3 lbs.	York	3052	24.3	9.1
Hydrated lime 3 lbs.	Stayman	1256	8.7	7.0
"Improved" calc. arsen —3 lbs.	York	1642	56.8	27.5
Skim milk powder—2 lbs.	Stayman	1329	29.3	27.0
Lead arsenate—3 lbs.	York	1834	7.4	5.2
Skim milk powder—3 lbs.	Stayman	1760	8.5	8.5

form of a darkened sunken ring about the blossom end, which in many cases involved the whole calyx basin. This injury was accompanied

by a serious yellowing and dropping of foliage, on which no counts were made. At State College, however, foliage injury from various spray combinations was studied on York and Stayman. The results are given in Table 2.

SPRAY RESIDUES.—Due to the small amounts of arsenicals applied and to the heavy August rains, no dangerous residues of arsenic or lead remained at picking time. Probably one more application could have been made without exceeding the tolerance. It is plain, however, that the general increase in codling moth populations in this section of Pennsylvania will force the use of an extended cover spray schedule.

SUBSTITUTES FOR LEAD ARSENATE IN SECOND BROOD SPRAYS.—Four count trees in each row were used, and the treatments ran at right angles to the first brood treatments, to include 6 count trees in each plot. Spraying was done by the writer, with the method and equipment used for the first brood sprays, and averaged 10 gallons per tree per application.

TABLE 3. SUBSTITUTES FOR ARSENIC FOR SECOND BROOD CODLING MOTH ROME ADAMS COUNTY, 1933

Applications July 25 and Aug. 8, without fungicide

Materials per 100 gals.	Time of Counts	Apples counted	Clean apples	Wormy apples	Live Larvae per tree	
		No.	%	%	No.	Incr.
1 No 2nd brood sprays...	1st brd. July 12*	1026	85.4	2.2	26	
	Tot. for season†	6501	30.5	43.7	668	25.7
2 Liq. Tan. acid—3 pints..	1st brd. July 12	1182	87.9	1.4	17	
50% free nic.—1 pint...	Tot. for season	7191	52.2	26.2	408	24.0
3 Pyrethrum ext.—1 pint.	1st brd. July 12	991	84.2	3.3	43	
40% soap—3 quarts....	Tot. for season	7458	56.2	25.2	432	10.0
4 Cuprous cyanide—2 lbs.	1st brd. July 12	1593	87.0	1.6	32	
	Tot. for season	11293	54.6	27.9	652	20.4
5 Summer oil—1 gal.....	1st brd. July 12	793	81.9	3.1	29	
40% nic. sulph—1 pint..	Tot. for season	4492	56.0	21.1	186	6.4
6 No 2nd brood sprays...	1st brd. July 12	740	84.6	1.9	13	
	Tot. for season	3802	31.3	48.8	439	33.8

*Vertical sample on 6 trees—not picked.
†All fruit—thinnings, drops, picked—6 trees.

In Table 3 the percentages of sound and wormy apples are influenced by the size of the crop as well as by the treatments applied. In this respect, however, blocks 2 and 3 may be compared with block 1 and block 5 with block 6. Figures from the infestation records have been used to compute the increase in number of worms per tree from the first brood counts to picking time. Without question, oil-nicotine in block 5 gave the best protection and greatest resistance to population

increase. As compared with check block 6, it raised the per cent clean fruit from 31.1 per cent to 56.0 per cent, decreased worminess from 48.8 to 21.1 per cent, and allowed a build-up of only 6.4 times the first brood population as against 33.7 times in the check. Pyrethrum-soap (block 3), cuprous cyanide (block 4) and nicotine tannate (block 2) follow in order of effectiveness.

None of the materials produced injury to trees or fruit, except that nicotine-oil left a rather dull finish in contrast to the bright lively red color in the other blocks.

CONCLUSIONS.—With proper consideration to the suppression of other apple insects and diseases, codling moth control in heavily infested orchards in southern Pennsylvania can be obtained best with 3 pounds of lead arsenate plus 2–3 pounds skim milk powder per 100 gallons, with liquid lime sulphur, and with nicotine sulphate in one application at the peak of first brood oviposition. The schedule should provide four cover sprays for the first brood of larvae, and one or two for the second brood. This practise will require washing of the fruit to remove arsenic and lead.

To avoid the necessity for washing, a substitute for lead arsenate should be used after the third cover spray on late varieties, and after the second cover spray on early varieties. Nicotine-oil is the most promising substitute, but its use is objectionable from the standpoint of cost and incompatibility with the standard fungicide. To avoid danger of injury, lime sulphur should be omitted from the spray next preceding the substitution of oil-nicotine, and this points to the necessity for good early season control of apple scab.

Copper cyanide, which doubtless possesses fungicidal as well as insecticidal properties, deserves further trial at increased concentration with stickers.

MODIFYING THE CODLING MOTH CONTROL PROGRAM

By LOREN B. SMITH and H. E. HODGKISS, *The Pennsylvania State College, State College, Pa.*

This paper deals with the results of an extension program modified to meet an emergency which Pennsylvania apple growers faced in the spring and early summer of 1933. The residue situation as the last spray season approached apparently placed a restriction on accepted insect control practices. This meant that the use of the usual insecticides would have to be greatly curtailed or else materials of unknown or questionable value would have to be substituted if the program of

codling moth control developed over a period of years was to be continued. A modified program of codling moth (*Carpocapsa pomonella*) control, therefore, was devised which it was believed would enable growers to obtain a fair degree of insect control and still be able to market their crop without the necessity of undertaking the removal of objectionable residues. The majority of Pennsylvania growers are as yet unequipped to remove spray residues.

Deciding on a program to meet the wide variety of topographic, climatic and insect conditions which occur in Pennsylvania is difficult, due to the great number of limiting factors which must be considered. In undertaking the modification of a program which had been demonstrated as being effective, it seemed best to make as few changes as possible in the accepted practices since in so doing there would be a greater chance of the growers conforming to the changes thus made. In presenting these results we are not attempting to evaluate materials or practices but are attempting to show what actually happened when these recommendations were used under the conditions obtaining in the commercial orchards.

THE SPRAY PROGRAM.—Until the past season the program followed for the control of the codling moth was based on the practice of applying from four to six sprays of lead arsenate at the rate of three pounds to each 100 gallons of spray material beginning with the petal fall application. It was found that the growers were obtaining more effective control when some spreader was used and for this reason powdered or liquid skim milk had been included in the recommendations. Nicotine sulphate at the rate of 1 pint to each 100 gallons is regularly added in the petal fall and again in the 10 day or cluster apple application in most counties for the control of apple red bugs. The addition of nicotine also in the second or third cover to coincide with the commencement of second brood egg laying has been demonstrated as a useful adjunct in reducing the numbers of the worms under conditions of heavy infestation. The last cover spray has heretofore been applied so that the spraying operations were completed by August 1st.

The program for 1933 was arranged in expectation that the least possible residue would remain on the fruit at harvest. Lead arsenate was the poison used. The first and second cover sprays contained 2½ pounds, the third and fourth called for only 2 pounds of lead arsenate. In the third cover spray there was an option of 3 pounds of calcium arsenate to each 100 gallons of spray. Two pounds of powdered skim milk were advised in each 100 gallons and 1 pint of nicotine sulphate was included in the second cover spray which was applied at about the

peak of hatching of the codling moth eggs. The sprays were timed to have the last spray completed by July 15. Under the modified program a total of only 9 pounds of lead arsenate was applied on a 100 gallon basis. This is compared to 12 pounds used in the regular program. Perhaps the greatest weakness in codling moth control programs is the manner in which the materials are applied and the growers were cautioned to make an extra effort to obtain complete coverage of the foliage and fruit.

THE CODLING MOTH SITUATION IN 1933.—Mild winters and previously favorable conditions resulted in a heavy carry-over of codling moth larvae. Emergence of moths began about petal fall time, or rather, collections began to be made in bait pails at that time following a rainy period during the mid-season bloom. Cool or damp weather prevailed and favorable egg laying conditions did not occur for nearly ten or twelve days, bringing it about June 1 in many counties when the cluster apple application was made. The worms began to appear in numbers between June 6 and 10 in the southern part of the state and the second cover spray was called about that time. The second brood was heavy and considerable damage occurred toward the latter part of August from late appearing worms.

As a means of timing the sprays, information was furnished by the Department of Zoology and Entomology to supplement bait pail collections made by local growers under our supervision at strategic points in those areas where the codling moth was most serious.

RESULTS OF THE MODIFIED PROGRAM IN A DEMONSTRATION ORCHARD.—As a means of determining the effectiveness of the modified recommendations under conditions where the infestation of codling moth was extremely severe, a portion of an orchard in Franklin County was selected and sprayed in accordance with the recommendations issued to the fruit growers. This orchard, although sprayed, lost about three-fourths of the crop in 1932 as result of codling moth attacks. The block selected consisted of 192 York and Gano trees 20 to 30 years old and 100 trees under that age, some of which were in bearing. All the recommended sprays were applied at the time specified and in accordance with the methods suggested in the spray letters issued to the growers. Two 300 gallon outfits were used each having 2 leads of hose and carrying 350 to 400 pounds pressure when in operation. The applications were made by the regular spray crews of the grower under our supervision. An average of 2,957 gallons of spray was used in application. Seven sprays were applied, the delayed dormant on April 24, the pink on May 3, the petal fall on May 17, and the cover sprays

on June 2, June 15, June 30 and July 18. Lime sulphur was used as the fungicide in each application to and including the first cover. Lead arsenate was used in the delayed dormant, pink and petal fall at the rate of 3 pounds to each 100 gallons of spray. It was reduced to 2½ pounds in the first and second cover sprays and to 2 pounds to each 100 gallons of spray in the third and fourth cover sprays. Two pounds of powdered milk was used to each 100 gallons of spray in the four cover sprays. One pint of nicotine sulphate was used in the petal fall, first and second cover sprays. No thinning was done on the demonstration or in the adjoining blocks.

The weather conditions at the time the sprays were applied were favorable. The temperature and humidity were both high when the first cover spray was made and although 3,700 gallons of material was used there was no appreciable russeting of the fruit. As a comparison the fourth cover spray was omitted on a portion of the demonstration block.

On August 26th a survey was made of the codling moth injuries in the demonstration block. This was done by counting 200 apples on each tree and recording the number and type of injuries. On 19 trees scattered throughout the block there were only 0.4 per cent of the fruit in which the worms had entered. Sixteen and four-tenths per cent of the fruit were "stung" which made a total of 16.9 per cent injured by codling moth. On that portion of the sprayed block where the last cover spray was omitted there were 2 per cent entries, 24.1 per cent "stung" making a total of 26.1 per cent injured fruit.

A count was made of the fruit in the main orchard which was sprayed by the grower and received all the applications except the fourth cover spray. Calcium arsenate was used in the third cover. No nicotine or spreader was used and it was found that 23.8 per cent of the fruits were "wormy," 42.6 "stung" which was a total of 66.4 per cent. In comparison with the demonstration block this was a difference of 23.4 per cent entries, 26.2 "stings" or an increase in the total damage of 49.5 per cent. Counts were made also on the upper and lower portions of the trees. There was 6 per cent more codling moth damage on fruit in the lower third than in the upper third of the trees.

At harvest a second count was made on both the demonstration block and the main orchard. Ten bushels of apples were counted from each block. Those from the demonstration block were 64.0 per cent clean, 35.9 per cent "stung" and only 13 apples had worm entries. The 10 bushels from the main orchard had 14 per cent free from codling moth injury, 38 per cent "stung" and 48 per cent of the apples were wormy.

The apples from the demonstration block were graded and packed by the grower. The balance of his crop was sold to the canners and cider mills for about 40 cents per hundred pounds of fruit. In this case had the grower used proper spray methods his crop would have yielded him approximately $45,000 more than he actually received.

COMPARISONS OF PRACTICES IN EASTERN PENNSYLVANIA.—In order to gain a general idea of the results of the modified schedule in a larger number of orchards, a survey was made during October in a number of counties in the eastern part of the state. Thirty-five orchards with a yield of 405,000 bushels of fruit received the full schedule of sprays recommended. There was an average of 3.8 per cent of the fruit injured by codling moth. Sixteen orchards with a yield of 97,000 bushels were sprayed with 3 pounds of lead arsenate in each 100 gallons in all the cover sprays instead of 2½ pounds. The codling moth damage amounted to 1.6 per cent. Thus under commercial conditions the use of 3 pounds of lead arsenate instead of 2½ pounds resulted in a reduction in codling moth damage from 3.8 per cent to 1.6 per cent.

Four orchards with a total crop of 100,000 bushels were sprayed with calcium arsenate in the fourth cover spray. The codling moth damage amounted to 6.2 per cent. Where calcium arsenate was used in both the third and fourth cover sprays 30.2 per cent of the fruit were injured by codling moth. In orchards where calcium arsenate was used in the third cover spray and the fourth cover spray was omitted, codling moth damage amounted to 39.5 per cent. These orchards produced 214,000 bushels of fruit. Lead arsenate was used in the first, second and third but the fourth cover spray was omitted in 21 orchards. Seven per cent of the fruit was injured by the worms.

CODLING MOTH IN EASTERN PENNSYLVANIA IN 1933

Treatment	Number of orchards	Total yield of orchards Bu.	Total bu. fruit uninjured	Total bu. fruit injured	Per cent of fruit injured
2½ lbs. lead ars. throughout season	35	405,000	389,930	15,070	3.8
3 lbs. lead ars. used throughout season	16	97,000	95,520	1,480	1.6
Calcium arsenate used in fourth cover	4	100,000	93,850	6,150	6.2
Calcium arsenate used in third and fourth cover	2	100,000	69,800	30,200	30.2
Calcium arsenate in third and fourth cover omitted	7	214,000	129,570	84,430	39.5
Lead ars. in all fourth cover omitted	21	160,000	148,918	11,082	7.0
Unsprayed	6	30,000	12,400	17,600	58.7

Three pounds of lead arsenate were recommended in all the cover sprays in 1932 and the codling moth damage in 36 completely sprayed orchards with a yield of 373,300 bushels was 1.8 per cent of the fruit. In 12 unsprayed orchards 28.9 per cent of the fruit was damaged by worms.

The data indicate a much heavier infestation of codling moth in 1933 than in 1932. Where 3 pounds of lead arsenate were used in either year the resultant control was approximately the same. A reduction in the amount of lead arsenate to 2½ pounds in 1933 gave about the same results as occurred when the final or fourth cover spray was omitted in 1932.

CONCLUSION.—The past season's experience in the control of the codling moth emphasizes certain fundamentals, namely; that the method of application of the sprays is one of the more important factors in obtaining effective results. Proper timing of the sprays is also an important factor influencing results. Materials substituted for lead arsenate in the Pennsylvania spray program have not proven effective in holding this insect in check. Using less than three pounds of lead arsenate to each 100 gallons of spray has resulted in greater codling moth damage than has heretofore occurred. Therefore the use of reduced dosages of lead arsenate in the future will not be recommended and our efforts will be centered on obtaining effective control even if these practices should result in the necessity for the spray residue removal.

COMPARATIVE TESTS OF ARSENICALS, ARSENICALS WITH OIL AND SEVERAL NICOTINE COMPOUNDS USED AGAINST THE CODLING MOTH[1]

By BYRLEY F. DRIGGERS, *Associate Entomologist* and B. B. PEPPER, *Research Assistant, New Jersey Agricultural Experiment Station*

Those departments of the New Jersey Agricultural Experiment Station responsible for outlining the spraying recommendations for apples for the season of 1933 were confronted with two general problems: (1) whether to recommend lead arsenate as the basic material on apples, to replace it with a non-lead arsenical, or to replace it with a non-arsenical and a non-lead spray; (2) outlining a program sufficiently flexible to fit the requirements of different groups of growers (the grouping being based upon codling moth, *Carpocapsa pomonella*, conditions in different parts of the state).

[1]Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

The work of McLean and Weber at this station on spray residue removal had reached a point where it was evident that under all normal orchard treatment conditions both arsenic and lead residues could be reduced below the federal tolerance figures. The non-lead arsenicals were uncertain in their control of insects and in their effect on foliage. The non-lead and non-arsenical substitutes either were due to come under tolerance figures or were considerably more expensive than lead arsenate. Therefore it was decided to stand by the usual lead arsenate recommendations.

The problem of preparing a properly flexible program involved: (1) provision for the single brooded areas where there is not enough codling moth to require spraying beyond July 1st but where in some instances a July spray is required to control apple maggot; (2) provision for the area having one and a partial second brood. Most orchards in this area require no more than one spray in July, thus requiring no washing on any late varieties of fruit. Some orchards in this area require two second brood codling moth sprays in July and a few require a Japanese beetle spray in late July. (3) Provision for the two brooded area, in which, in most instances, codling moth requires two or three sprays after July 1st and in which in many instances orchards are so heavily infested with codling moth that the growers can not hope to grow a reasonably clean crop with ordinary lead arsenate sprays.

The result of the effort to meet the various spray requirements is set forth in New Jersey extension bulletin 102 supplemented by a mimeographed statement. In this bulletin and statement the following materials or combinations of materials were recommended: (1) lead arsenate, (2) lead arsenate with summer oil, (3) nicotine tannate and (4) nicotine sulfate with summer oil. The last two combinations were recommended in the later sprays as substitutes for lead arsenate to avoid washing the fruit. The nicotine tannate and the nictoine-oil had to be applied more frequently in the later sprays than lead arsenate in order to protect the fruit because these materials disappeared more readily.

The field spraying tests on apples for 1933 were run to test the relative effectiveness of these four materials or combination of materials. Calcium arsenate with and without summer oil was tested because it represented one of the possible arsenical substitutes for lead arsenate. Several compounds for carrying and fixing nicotine were tested also in cooperation with the Tobacco By-Products and Chemical Corporation. Previous work had shown that bentonite or compounds containing bentonite had the ability to fix nicotine to a marked degree. In addition

one-half the usual charge of nicotine tannate plus one quart of summer oil to 100 gallons of spray was tested. The calcium arsenates, the fixed nicotine compounds and the combination of nicotine tannate and summer oil were tested on small blocks because the materials or combinations were new and because there was a possibility of foliage injury.

DESCRIPTION OF THE EXPERIMENTAL BLOCKS AND TREATMENTS.—The orchard selected for the summer spraying experiments was located in the two-brooded codling moth area near Glassboro. Practically no clean fruit had been picked from this orchard the previous two years due to the severity of the codling moth infestation. Stayman trees approximately thirty years old were selected for laying out the blocks. About the middle of April, after most of dormant season larvae mortality had taken place, five representative trees in this Stayman block were examined carefully from the top to the ground to determine the average population of live larvae per tree. This orchard had been banded with burlap bands the year before but the bands had not been cared for, consequently the majority of the bands had fallen from the trees the previous winter and summer or had been pulled off by birds. Five trees which had retained their bands all winter were selected for examination. These five trees averaged 62 live larvae per tree under the bands and 118 per tree exclusive of the band larvae. From these figures it seems reasonable to assume that the trees making up the experimental blocks carried an overwintering moth population of 150 or more per tree.

Four blocks were laid out containing from 40 to 55 trees each. These four blocks were used to test (1) lead arsenate, (2) lead arsenate-oil, (3) nicotine-oil and (4) nicotine tannate. Several small blocks of 8 trees each were laid out to test those materials which were new or which were liable to give burning. The writers took over the spraying of the blocks at the petal fall spray. Before that time the sprays designed to control aphis and scab were either omitted by the grower or else were inadequately applied. As a result aphis and scab did considerable damage before and after the blocks were taken over for the codling moth sprays. Unfavorable weather during the blooming period together with aphis and scab injury brought about a set of fruit not more than 20 per cent of normal. The light crop of fruit plus a heavy codling moth population plus the fact that the trees were not scraped until 90 per cent of the overwintering moths had emerged indicated a heavy first brood codling moth attack. This suited our purpose which was to bring out differences in the effectiveness of the different spray materials.

All blocks were sprayed the same at the petal fall application which consisted of commercial lime sulfur 8 quarts and lead arsenate 3 pounds

TABLE 1. SUMMARY OF SPRAY MATERIALS USED AS COVER SPRAYS ON CODLING MOTH EXPERIMENTAL BLOCKS AT GLASSBORO DURING SUMMER OF 1933

Block	Total trees in block	Materials applied in 100 gallons		Number of cover sprays[4]	
		First brood	Second brood	1st brood	2nd brood
1	48	L. A.[1] 4 lbs., Bentonite sulfur 8 lbs., milk 1 lb. in 3 sprays. L. A. 4 lbs., lime 8 lbs., milk 1 lb. in 1 spray.	L. A. 4 lbs., lime 8 lbs., milk 1 lb.	4	5
2	40	L. A. 2 lbs., Coposil 12 lbs., lime 4 lbs., fluxit ½ lb. orthol K oil 3 qts., in 3 sprays. L. A. 4 lbs., lime 8 lbs., fluxit ½ lb., in one spray.	L. A. 2 lbs, Orthol K oil 3 qts., fluxit ½ lb., in 2 sprays. L. A. 4 lbs., lime 8 lbs., fluxit ½ lb., orthol K oil 1 qt., in 3 sprays.	4	5
3	40	L. A. 2 lbs., Coposil 12 lbs., lime 4 lbs., fluxit ½ lb., orthol K oil 3 qts., in 3 sprays. Nicotine sulfate 1 pt., orthol K oil 3 qts., in 1 spray.	Nicotine sulfate 1 pint, orthol K oil 3 qts.	4	7[3]
4A	28	Nicotine tannate[2], bentonite sulfur 8 lbs.	Nicotine tannate	4	7[3]
4B	28	Nicotine tannate, bentonite sulfur 8 lbs.	Nicotine tannate, bentonite sulfur 6 lbs.	4	7[3]
5	8	"Corona" calcium arsenate 3 lbs., bentonite sulfur 8 lbs., milk 1 lb. in 3 sprays. "Corona" calcium arsenate 3 lbs., lime 8 lbs., milk 1 lb. in 1 spray	"Corona" calcium arsenate 3 lbs., lime 8 lbs, milk 1 lb.	4	5
6	8	"Calrox" cal. ars. 3 lbs., bentonite sulfur 8 lbs., milk 1 lb. in 3 sprays. "Calrox" cal. ars. 3 lbs., lime 8 lbs., milk 1 lb. in 1 spray	"Calrox" calcium arsenate 3 lbs., lime 8 lbs., milk 1 lb.	4	5
7	8	"Calrox" cal. ars. 1½ lbs., coposil 12 lbs., lime 4 lbs., fluxit ½ lb., orthol K oil 3 qts. in 3 sprays. "Calrox" cal. ars. 3 lbs., lime 8 lbs., fluxit ½ lb. in 1 spray	"Calrox" cal. ars. 1½ lbs., orthol K oil 3 qts., fluxit ½ lb. in 2 sprays. "Calrox" cal. ars. 3 lbs., lime 8 lbs., fluxit 1 lb., orthol K oil 1 qt. in 3 sprays	4	5
8	8	Bentonite sulfur 8 lbs., nicotine sulfate 1 pt., soap 2 lbs.	Bentonite sulfur 6 lbs., nicotine sulfate 1 pt., A. S. S.[5] 2 lbs.	4	5
9	8	Formula 155 (Bentonite, nicotine sulfate, soap) 8 lbs.	Formula 155 (Bentonite, nicotine sulfate, A. S. S.) 8 lbs.	4	5
10	8	½ charge nic. tannate, orthol K oil 1 qt.	½ charge nic. tannate, orthol K oil 1 qt.	4	7[3]

[1]Lead arsenate powder.
[2]Nicotine tannate formula: 3 pints liquid tannic acid and 1 pint 50% free nicotine to 100 gallons water.
[3]Applications on second brood on these blocks at intervals of 7 days; all other applications at ten day intervals.
[4]Spray dates for blocks on 10 day schedule: June 4, 14, 23, July 6, 17, 27, Aug. 7, 26, Sept. 8. Spray dates for blocks on 7 day schedule: June 4, 14, 23, July 6, 14, 21, 28, Aug. 4, 15, 28, Sept. 8.
[5]Ammonium-sulfo-soap.

to 100 gallons. All blocks except the nicotine tannate block were sprayed the same at the 7-days-after-petal-fall application with dry flotation sulfur 5 pounds, lead arsenate 3 pounds, Orthol dry spreader (similar to Fluxit) ½ pound and hydrated lime 15 pounds to 100 gallons of water. Free nicotine at the rate of from ⅓ to ⅔ pint per 100 gallons was added in an effort to reduce aphids. The nicotine tannate block was sprayed with free nicotine 2 pints, tannic acid (50%) 3 pints and dry flotation sulfur 5 pounds to 100 gallons. The extra pint of free nicotine in the spray on this block was added to reduce aphids. Beginning with the 17-days-after-petal-fall, or first codling moth cover spray, the blocks began receiving the different spray materials designed to control codling moth. Table 1 gives the number and size of the blocks, the spray materials and the number of applications applied during first and second broods.

Several points in connection with the data in Table 1 should be clarified. Blocks 4A and 4B began the season as block 4 which explains the reason why they were sprayed the same during first brood. This block was divided into blocks 4A and 4B and sprayed during second brood as indicated in Table 1. In footnote (4) of Table 1 it will be noted that the interval between sprays in the middle of August was longer than either the ten or seven day intervals being followed. Weather conditions prevailing at that time prevented spraying the blocks on schedule.

METHODS USED TO MEASURE RESULTS.—Several methods were used to bring out the differences in degree of control of codling moth on the various blocks. The usual method of marking certain trees in each block and scoring all the fruit on these trees at harvest was followed. Dropped fruit on these same marked trees was picked up every week from the first of July (after the so-called June drop was over) until the fruit was harvested in October. As a further check these marked trees were thoroughly scraped, banded with burlap bands and the larvae recorded weekly throughout the season. Four hundred apples on each of several trees in each block were examined after first brood larval entry had ceased in order to get a rough estimate of how the blocks had stood up through first brood. This was done in all of the blocks except 5, 6 and 7. Lack of time prevented examining all the blocks.

The usual method of recording codling moth injury is to score the fruit as "deep entry" (wormy) or "shallow entry" (stings). Since codling moth injury ran as high as 90 per cent of the harvested fruit in some of the blocks, it was decided to divide the stung fruit into 3 groups depending on the number of stings per apple. The difference in the intensity of stinging, it was believed, could be brought out in this manner.

RESULTS.—From July 7 to July 17, twenty-four hundred apples on six trees in each of blocks 1, 2, 3 and 4 were examined. Eight hundred apples on two trees in each of blocks 8, 9 and 10 were examined during the same period. The fruit (examined from top, middle and bottom of the tree) was scored for codling moth injury. The data obtained from these first brood counts are set forth in Table 2.

TABLE 2. PER CENT CODLING MOTH INJURED APPLES ON TREE AT END OF FIRST BROOD IN SEVEN OF THE EXPERIMEMTAL BLOCKS AT GLASSBORO

Block	Treatments*	No. examined		Apples injured
		Trees	Apples	%
1	Lead arsenate	6	2400	63.8
2	Lead arsenate-oil	6	2400	51.6
3	Lead arsenate-oil	6	2400	48.0
4	Nicotine tannate and bentonite sulfur	6	2400	40.5
8	Nicotine sulfate and bentonite sulfur	2	800	48.5
9	Nicotine sulfate and bentonite	2	800	53.4
10	½ charge nic. tan. and 1 qt. oil	2	800	62.0

*For complete details of treatments on these blocks see Table 1.

The important point brought out by the data in Table 2 is that nicotine tannate and bentonite sulfur (block 4) held up under first brood codling moth attack better than either lead arsenate (block 1) or lead arsenate-oil (blocks 2 and 3). Larval catch from the bands at that time supported these figures as shown in Table 5. The results obtained from the first brood counts led us to examine carefully the part bentonite sulfur was playing in prolonging the effectiveness of the nicotine tannate. One of the methods used to determine this point was to divide

TABLE 3. PER CENT CLEAN AND CODLING MOTH INJURED APPLES INCLUDING DROPPED AND PICKED FRUIT ON EXPERIMENTAL BLOCKS AT GLASSBORO

Block No.	Treatment*	Count trees	Total apples	% Apples injured			% Clean apples
				Stung	Wormy	Total	
1	Lead arsenate	6	6348	74.4	14.7	89.1	10.9
2	Lead arsenate-oil	6	5403	58.9	27.8	86.7	13.3
3	Lead arsenate-oil and nicotine sulfate-oil	6	6399	46.3	19.6	65.9	34.1
4A	Nicotine tannate and bentonite sulfur, then nicotine tannate	4	5334	38.3	17.2	55.5	44.5
4B	Nicotine tannate and bentonite sulfur	4	4879	32.1	16.3	48.4	51.6
5	Calcium arsenate	2	2638	50.1	42.7	92.8	7.2
6	Calcium arsenate	2	2040	69.5	20.8	90.4	9.6
7	Calcium arsenate-oil	2	1494	61.8	28.1	90.0	10.0
8	Nicotine sulfate-bentonite sulfur	2	1666	44.7	24.2	68.3	31.7
9	Nicotine sulfate-bentonite	2	1406	31.5	34.2	66.5	33.5
10	½ nicotine tannate-oil	2	1514	46.9	32.7	79.0	21.0

*See Table 1 for complete details of treatments on these blocks.

block 4 into two halves and spray one-half during second brood with nicotine tannate and continue spraying the other half with nicotine tannate and bentonite sulfur.

The fruit on the marked trees was harvested the second week in October. Table 3 sets forth (1) the number of trees harvested and all the fruit examined; (2) the per cent stung, wormy and total injury by codling moth and (3) the per cent clean fruit for each block. The drop fruit, collected weekly from July to harvest, is included in with the picked fruit.

Table 4 sets forth the total harvested fruit on each block and the percentage of this fruit having 1–3 stings, 4–8 stings and 9 stings or above.

TABLE 4. PER CENT HARVESTED FRUIT SHOWING 1–3 STINGS, 4–8 STINGS AND 9 STINGS OR ABOVE

Block	Treatment*	Total fruit	Per cent apples showing 1–3 stings	4–8 stings	9 or more stings
1	Lead arsenate	5157	33.4	33.9	14.2
2	Lead arsenate-oil	4010	31.9	30.4	9.1
3	Lead arsenate-oil then nicotine sulfate-oil	4745	48.5	5.6	0.0
4A	Nicotine tannate-bentonite sulfur then nicotine tannate	3931	39.7	1.1	0.0
4B	Nicotine tannate-bentonite sulfur	3702	33.4	0.5	0.0
5	Calcium arsenate	1696	17.2	24.4	25.3
6	Calcium arsenate	1644	26.3	30.7	21.6
7	Calcium arsenate-oil	1116	30.3	31.3	13.6
8	Nicotine sulfate-bentonite sulfur	1278	42.4	7.7	0.0
9	Nicotine sulfate-bentonite	1038	36.7	13.5	0.0
10	½ nicotine tannate-oil	1058	41.4	9.8	0.5

*See Table 1 for details of block treatments.

Table 5 sets forth the larval catch under bands in each block for the season, for each brood and the average larval catch per tree for each brood.

TABLE 5. NUMBER LARVAE CAUGHT UNDER BANDS FOR THE SEASON, FOR EACH BROOD AND THE AVERAGE NUMBER LARVAE CAUGHT PER TREE PER BROOD

Block	No. trees banded	Number larvae Season	First brood	Second brood	Larvae per tree First brood	Second brood
1	6	281	188	93	31	15
2	6	440	350	90	58	15
3	6	405	351	54	58	9
4A	3	148	97	51	32	17
4B	3	165	143	22	48	7
5	2	256	120	136	60	68
6	2	90	62	28	31	14
7	2	101	65	36	32	18
8	2	74	28	46	14	23
9	2	96	58	38	29	19
10	2	98	58	40	29	20
Totals	36	2154	1520	634	42.2	17.6

DISCUSSION OF RESULTS.—Table 3 shows that block 4B (nicotine tannate and bentonite sulfur both broods) came through the season with the highest amount of clean fruit which was 51.6 per cent. The next best block was 4A (nicotine tannate-bentonite sulfur first brood then nicotine tannate second brood) with 44.5 per cent clean fruit. Following these two blocks came blocks 3 (lead arsenate-oil then nicotine sulfate-oil), 9 (nicotine sulfate-bentonite), and 8 (nicotine sulfate-bentonite sulfur) with 34.1, 33.5 and 31.7 per cent clean fruit respectively. Block 1 (lead arsenate), 2 (lead arsenate-oil), 5 (calcium arsenate), 6 (calcium arsenate) and 7 (calcium arsenate-oil) all ranged around 10 per cent clean fruit. Block 10 (½ charge nicotine tannate and 1 quart oil) came through with 21 per cent clean fruit.

If we examine the figures under the column labeled "per cent wormy apples" we find that there was not a great deal of difference between blocks 1, 3, 4A and 4B. They ranged between 15 and 20 per cent. The calcium arsenate and the fixed nicotine blocks ranged from 20 to 43 per cent wormy fruit. The surprising difference in this column is between block 1 (lead arsenate) and block 2 (lead arsenate-oil). Block 2 showed approximately twice as much wormy fruit as block 1. A possible explanation for the failure of the lead arsenate-oil to control as well as the straight lead arsenate presents itself. If we examine Table 1 we find that on block 2 during first brood when three oil sprays were being applied, the total solids to one hundred gallons was around 12 pounds. It is conceivable that these solids would tend to reduce the ovicidal efficiency of the 3 quarts of oil to 100 gallons which was used. At the same time that the ovicidal efficiency of the oil was reduced the lead arsenate charge was reduced from 4 to 2 pounds to 100 gallons. The reduced lead arsenate charge would tend to allow more larvae to get through the poison coating.

The data in Table 4 show the relative intensity of stinging in the different blocks. With the heavy moth population and light crop we would expect heavy stinging where lead arsenate alone is used. Therefore, we find block 1 (lead arsenate) with 33.4 per cent of the harvested fruit with 1–3 stings, 33.9 per cent with 4–8 stings and 14.2 per cent with 9 or more stings. Block 2 (lead arsenate-oil) was little better than block 1 in respect to intensity of the stinging. The calcium arsenate blocks likewise show a high percentage of the fruit with more than three stings. On the other hand those blocks which received nicotine in one form or another showed a relatively low percentage of the fruit with more than 3 stings. Block 4B (nicotine tannate-bentonite sulfur both broods) had practically no apples with more than 3 stings.

The data in Table 5 show that the standard lead arsenate was more effective than lead arsenate-oil in preventing wormy fruit. Twice as many larvae were caught under bands during first brood in blocks 2 and 3 (lead arsenate-oil) than were caught on block 1 (lead arsenate). On second brood the difference between these blocks was not evident due probably to a build-up of lead arsenate on the lead arsenate-oil blocks by the time second brood larvae were hatching.

If we examine the figures on larval catch for blocks 4A and 4B for first brood we find that fifty per cent more larvae were caught on the trees in block 4B than in 4A in spite of the fact that the trees in the two blocks received the same treatment of nicotine tannate and bentonite sulfur. It appears, therefore, that the trees in 4B were potentially greater worm producers due either to more fruit or to the difficulty of keeping the fruit covered or to both. During second brood we find the larval catch reversed. There were 2½ times more larvae recorded from the trees in block 4A during second brood than were recorded from block 4B. These data support the data in Table 3 which show that nicotine tannate-bentonite sulfur was more effective than nicotine tannate alone in preventing larval entry.

Since past experience indicated that in the full two brooded codling moth area second brood larvae caused from three to four times as much damage as the first brood, the results indicate that a more than ordinary control of first brood was obtained. This was brought about by thorough and timely applications of the spray materials. In spite of the timeliness and thoroughness of spray applications it was found that fruit in the tops of the trees was not properly covered. Spraying from the ground as we did was not sufficient to obtain adequate coverage of the fruit in the top of the trees even though spray guns were used. Consequently it was estimated that more than 75 per cent of the larvae which successfully matured during first brood did so in fruit from the top of the trees.

SUMMARY AND CONCLUSIONS.—Summer spraying tests on apples to control codling moth were run in which lead arsenate, lead arsenate-oil, nicotine sulfate-oil, nicotine tannate-bentonite sulfur, calcium arsenate and nicotine sulfate with bentonite were the principal materials compared. All blocks were sprayed the same during first and second brood on a ten day schedule except the nicotine sulfate-oil and nicotine tannate blocks which were sprayed on a seven day schedule during second brood. The results were determined by fruit examinations at the end of first brood and at harvest, by examining dropped fruit and by collecting larvae under bands. These data show clearly that nicotine tannate when used with bentonite sulfur gave a better control of codling moth

than any of the other materials. The data also indicate that nicotine tannate alone is not as effective as nicotine tannate with bentonite sulfur. Nicotine sulfate with bentonite, nicotine sulfate with bentonite sulfur, a half charge of nicotine tannate with oil and nicotine sulfate with oil all produced more clean fruit than either the standard lead arsenate or lead arsenate with summer oil. The standard lead arsenate treatment was superior to lead arsenate with oil in preventing wormy fruit due, it is believed, to a reduction in the lead arsenate charge where oil was used and to a lowering of the ovicidal action of the oil in the presence of a heavy charge of solids. Calcium arsenate with or without oil was not as effective as the standard lead arsenate treatment. More wormy fruit was produced on the calcium arsenate blocks as well as more and deeper stings. No pronounced foliage injury was observed on the calcium arsenate sprayed trees. This lack of burning when calcium arsenate was used may have been due in part at least to the hardiness of the trees and to the fact that other materials were present in the spray with calcium arsenate and may have acted to prevent arsenic burn.

A marked reduction in the codling moth population was obtained by the first brood spraying. This reduction was so pronounced that second brood attack was only about a third as severe as first brood attack. This is in contrast to previous years experience where second brood injury was usually three or four times greater than that of first brood. Chemically treated bands which were used during the season no doubt helped to reduce the number of first brood larvae pupating and thereby helped reduce the severity of second brood attack. Those larvae that did mature to produce second brood moths came principally from the inadequately protected fruit in the tops of the trees. Our experiments this past summer emphasize the importance of smashing the first brood of larvae by timely and thorough applications of whatever spray materials are used.

A DEFOAMING MATERIAL FOR USE IN APPLE WASHING MACHINES

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Certain wetting agents increase the efficiency of washing solutions used for removal of arsenic and lead spray residues from apples. Weber and McLean (1) found that Vatsol or Alkanol B were of value for this purpose when used with dilute hydrochloric acid. Robinson (2) has published results showing that in some cases the use of Vatsol increases the efficiency of hydrochloric acid. Overley et al (3) indicated that the addition of a wetting agent or a soap sufficient to cause foaming increased the efficiency of "BW" silicate in heated solutions. When Vatsol is used with the washing solution in a flotation washer no foaming takes place. In commercial washers of the spray or flood-type, excessive foaming occurs when Vatsol in amounts larger than 4 ounces to 100 gallons is used.

Any material which is added to the wash solution to control the foam, in order to be practical, should have the following specifications: (1) It must be cheap; (2) It must spread on water; (3) It must be of high molecular weight; (4) It should be liquid or of low melting point; (5) It must not interfere with residue removal; (6) It should not have an objectionable odor; (7) It should leave the apples in good packing condition; (8) It should preferably be effective in both dilute acid and dilute alkali. Our Technical Laboratory investigated various chemical compounds and mixtures on an experimental basis, with the above requirements as an objective.

On the basis of Langmuir's theory of the orientation of molecules at a surface, in order that a compound may spread on water it must be composed of a water-insoluble part and of a water-soluble part. The compound must have the general formula RX where R represents an organic water-insoluble part and X represents a water-soluble COOH, OH or other water-soluble group. At an air-water interface, the compound will orient itself as follows:

Air	R
Water	X

Such a compound will spread on a water surface. A hydrocarbon compound will not spread on water and it can have no appreciable antifoam properties, since it would require excessive amounts to form a layer of material on a water surface.

An antifoam, besides possessing other properties, must contain at least eight carbon atoms. Some of the forty-two compounds tested by the laboratory are listed.

LITTLE OR NO ANTIFOAM PROPERTIES.—Dipentene, pinene, cellosolve, carbitol, butyl carbitol, aldol, benzyl alcohol, phenyl ethyl alcohol, cetyl alcohol, sperm oil.

ANTIFOAM PROPERTIES, BUT OBJECTIONABLE FOR OTHER REASONS.—Alpha terpineol, beta terpineol, oleic acid, lauric acid, cocoanut fatty acids, Turkey Red oil, oleyl alcohol, caprylic alcohol, secondary hexyl alcohol, fenchyl alcohol, du Pont higher alcohols.

Our Technical Laboratory suggested that DeGras (wool grease) should be a good antifoam and might meet our other specifications. This material is a complex mixture of esters of fatty acids and of alcohols of high molecular weight. It was mixed with naphtha to secure mobility and under laboratory conditions exhibited satisfactory foam control.

Field tests were made in Burlington County, New Jersey, in a Cutler flood washer and Bean spray-type washer. Apples used in the tests came from an orchard which received nine oil-lead cover sprays after June 1st. The last spray was applied about September 4th. These apples were hand-picked from the lower outside branches of the trees, and represented the maximum load of residue carried by the fruit on these trees. It is only by using samples of this nature that the variation in residue carried by apples from various parts of the tree can be reduced to a minimum and the samples of apples used in the various treatments can be compared. The field tests indicated that 0.3% to 0.5% of DeGras-naphtha mixture gave fairly permanent foam control. It was inexpensive, did not injure the fruit under the conditions of our tests, and had no unpleasant odor. It did not interfere with residue removal as had been the case with some of the compounds which were tested.

The table shows the lead residue remaining on some of the samples of apples receiving various treatments. In considering these figures it should be remembered that they represent samples carrying an extreme load and are in excess of the average load carried by the orchard run of fruit. The spray schedule was extremely heavy. We may conclude that, when fruit carries this load and when mineral oil has been used in the spray, the commercial washer must be slowed down in order to provide that the apples shall remain exposed to the action of the wash solution for a fairly long period of time, particularly if the wash solution is not heated. The DeGras antifoam mixture did not interfere with residue removal.

LEAD RESIDUES REMAINING ON APPLES AFTER WASHING

Treatment	Seconds in wash solution		Cutler flood washer Grimes 1	Cutler flood washer Grimes 1	Cutler flood washer Staymen 2	Bean washer[1] Grimes 3	Bean washer[1] Grimes 3
	Cutler	Bean	60°F.	100°F.	62°F.	70°F.	100°F.
Unwashed			.230	.230	.134	.226	.226
1.75% HCl	24	27	.060	.041	.059	.062	.044
1.75% HCl 1% Vatsol 0.5% No. 16	24	27	.035	.018	.035	.057	.037
1.75% HCl	48	54	.035	.020	.030	.046	.033
1.75% HCl 1% Vatsol 0.5% No. 16	48	54	.014	.012	.013	.034	.018

No. 16 Antifoam—50% DeGras + 50% Naphtha.
Lead residue expressed as gr./lb.
Grimes 1—Picked and Washed 9/13/33.
Staymen 2— " " " 10/ 5/33.
Grimes 3— " " " 9/18/33.

[1]Bean old-style washer

Following our field tests with the DeGras-naphtha mixture, a packing house operator in New Jersey, who wished to use the acid-Vatsol wash in a commercial washer, began the use of the mixture in his routine operations. Approximately 20,000 bushels of several varieties of apples (Grimes, Delicious, Golden Delicious, Stayman, Jonathan) have been washed and placed in storage. Some of these apples have been under observation for a period of two months, and no injury has been found. This anti-foam mixture is being tested by workers in other states, both in unheated and in heated solutions. As a result of these preliminary tests, it would appear that DeGras thinned with petroleum naphtha may be used to control excess foaming when Vatsol is used with certain washing compounds in commercial apple washing machines where agitation is present.

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ALFALFA PLANTS RESISTANT TO THE PEA APHID

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During investigations of the pea aphid in the Antelope Valley in southern California and in Wisconsin, observations were made independently by the authors of occasional alfalfa plants resistant to damage by the pea aphid (*Macrosiphum pisi* Kalt.).

OBSERVATIONS IN CALIFORNIA.—Field observations in the Antelope Valley of southern California, during the seasons 1930 to 1933 inclusive, showed that occasional alfalfa plants had in some cases been heavily infested but that the aphids had died before causing noticeable signs of damage. Seed harvested from two of these plants, in 1930, was planted that fall, in a caged area in the field from which it was taken. No plants grew from this seed. Cuttings were made from undamaged alfalfa plants that were growing in the field during the spring seasons of 1931 to 1933 inclusive. Seventy plants that resulted from the cuttings, made during 1931 and 1932, were planted in the fall of 1932 in a field where severe aphid damage has occurred yearly since the field was seeded. A second series of 20 widely separated plants which seemed to be making usual growth in another badly damaged field were marked on March 31 and April 1, 1933. Ten of these plants were damaged subsequently by aphids which migrated to them from surrounding plants, and 10 plants remained undamaged throughout the season. Six of these undamaged plants appeared to be of the usual habit of growth for this variety but 4 of them displayed a low spreading type of growth. The plants of the usual habit of growth were removed from the field and replanted in the laboratory garden at Sacramento, in order that seed might be obtained from them. Nine other undamaged plants, taken from five badly damaged fields, were removed to the Sacramento laboratory for possible seed. Cuttings were obtained from 26 other plants which showed apparent resistance to aphids. In all cases where the plants were dug or cuttings made, all the immediately surrounding plants had been very seriously damaged or their growth destroyed by aphids. Some of the plants appeared to have portions of their growth damaged or destroyed by aphids, but upon being dug it was found that there were 2 or more plants present and that they had their roots intertwined. In some cases the damaged growth of one plant was intermixed with the normal

growth of another. All the plants dug up were examined for symptoms of bacterial wilt but all appeared to be free from that disease.

The 70 plants, from cuttings made in 1931 and 1932, were observed throughout the spring of 1933, and attempts were made to establish aphid colonies upon them but without success. Hundreds of aphids taken from the nearby badly damaged field were placed on or near each plant on two occasions but they did not become established. The plants were spaced about one foot apart, which is not a normal condition, but it was observed that other isolated plants near this same plot were fed upon by aphids and badly damaged.

The variety of alfalfa represented by the resistant plants is uncertain, as there is considerable mixture of seed in the area where they were found. Chilean, one of the common alfalfas, and Hairy Peruvian are the varieties generally grown in the section. Some of the plants seem to be able to make normal growth under lower temperatures than do the surrounding susceptible plants. Seed is being obtained from the segregated plants as rapdily as possible and further field and cage tests as to aphid resistance will be made. This work is being carried on in cooperation with the agronomy division of the University of California.

OBSERVATIONS IN WISCONSIN.—During the life-history studies of the pea aphid on potted alfalfa plants in the field insectary, two plants were discovered, in the spring of 1931, upon which newly born aphids would not live.

In 1932, some 225 alfalfa plants were raised from seed of the Grimm variety. Three of these were found incapable of supporting aphids, as routine transfers of newly born nymphs were made in the insectary. One plant, of the 1932 series, died and the other two were tested with adults and nymphs, but all aphids placed on them were dead or had disappeared in from two to five days.

These two plants were multiplied vegetatively in the greenhouse during the winter 1932–1933, and 23 of the progeny were tested the next spring to see if they showed the resistance to aphid feeding which the parent plants had shown. These plants were caged separately, and 186 adults and late-instar nymphs were placed upon them. At the end of the second day 72 newly born nymphs were observed, but their numbers subsequently decreased.

Two plants became uninfested in four days, 12 in six days, 20 in nine days, and all became uninfested in sixteen days. The great majority of the original aphids were found dead, but very few small nymphs could be found after they had disappeared from the plants.

As a starvation test, 247 adults and fourth-instar nymphs were confined in fine-mesh cages on moist sand. Eighty-six were dead in two days, 236 were dead or had disappeared in four days, and all were dead or had disappeared in six days.

As a check, 32 adults and late-instar nymphs were confined on two sets of three unselected plants each. On one set, which was discontinued after nine days, there were 423 live aphids and 3 dead adults. The other set, discontinued after eleven days, had 453 live aphids and 49 dead adults.

Twenty-five plants which were the progeny of the two original ones were allowed to go to seed. The seed was planted and when the plants were large enough to test, in the latter part of May 1933, a total of 74 adults and late-instar nymphs were caged on 11 plants. At the end of five days 7 plants became uninfested. At the end of six days, 9 plants were uninfested and all became uninfested at the end of seven days. Practically no newly born nymphs were found on any of the plants.

As a check, 3 unselected plants were caged with 20 adults. At the end of seven days there were 400 living aphids on them.

It was noticeable that the adults confined on resistant plants soon became shrunken and dark green, typical of adults occurring in late summer during the hot weather. The majority of confined aphids were very restless, dropped readily from the plants, and tried to crawl away.

Temperature is believed to be an important factor in the longevity of aphids on these plants. In the several series of tests here condensed, the higher the average temperature, and especially the higher the maxima, the shorter the time the aphids lived.

LYGUS HESPERUS KNIGHT (HEMIPTERA, MIRIDAE) IN RELATION TO PLANT GROWTH, BLOSSOM DROP, AND SEED SET IN ALFALFA[1]

By W. EARL SHULL, PAUL L. RICE and HARRY F. CLINE, *Department of Entomology, University of Idaho*

Sorenson (1932) shows that the tarnished plant bug, *Lygus pratensis* Linn., and the superb plant bug, *Adelphocoris superbus* (Uhler) cause blossom drop of alfalfa in Utah, and that the amount of drop caused by these insects varies with the increase of the populations of the insects. Shull (1933) has shown that the two insects, *Lygus hesperus* Knight and *Lygus elisus* Van Duzee, are found in large numbers in certain parts of Idaho. Field observation has shown that, where the population of the insects was high in alfalfa seed fields, there was often a large loss in the seed crop. The tarnished plant bug, *Lygus pratensis* Linn., is not now known to be present in Idaho.

Screen wire cages as used by Shull (1933) were again used to confine the legume bug, *Lygus hesperus*, to individual alfalfa racemes. Each flower on the caged racemes was artificially pollinated. All of the cages were placed on alfalfa plants which were growing out-of-doors and were protected from direct sunshine by a muslin shade. The effect of the legume bug on blossom drop and on seed formation was studied in these cages. The effect of *Lygus hesperus* and *Lygus elisus* on the growth of alfalfa plants was studied in four cages made by covering wooden frames with muslin. These cages were placed over alfalfa plants growing in the field. Each cage covered an area of 12½ square feet. The cages were made high enough to allow for the growth of the plants.

The four cages used in the study of the effect of the insects on the growth of the plants were placed over the alfalfa plants on June 27, 1931. Three weeks later *Lygus hesperus* and *Lygus elisus* were introduced into the cages. Insects of both species were placed in each of the cages numbered 2 and 4 (Table 1). Cages numbered 1 and 3 were used as check cages in which no insects were introduced. Six introductions of insects were made into Cages 2 and 4 on various dates throughout the summer until a total of 1123 had been introduced into Cage 2 and 1772 had been introduced into Cage 4. The last introduction was made on August 6. Enough live insects were kept in the cages at all times so that the populations approximated those present in the surrounding fields. On August 15 the hay from the cages was harvested and weighed. The

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cages were placed very close together in the field so that they might be on the same type of soil and might receive the same amount of irrigation water. The approximate number of plants under each cage was the same. Table 1 gives the weights of hay which was produced in each cage.

TABLE 1. WEIGHTS OF ALFALFA HARVESTED FROM CAGES ON AUGUST 15, 1931

Cage No.	Number of alfalfa plants	Weight of green alfalfa	Number of *Lygus* introduced	Per cent injury
1	17	69.0 oz.	None	0
2	18	59.0 oz.	1123	14.34
3	19	65.5 oz.	None	0
4	20	58.0 oz.	1772	20.61

The weight of hay produced in Cage 2 was 10 ounces less than was produced in the corresponding check cage, while the yield in Cage 4 showed a difference of 13.5 ounces. In both cases there was one more plant in the cages containing insects than there was in the corresponding check cages. The average percentage difference in Cages 2 and 4 is 17.5 per cent less hay than in the check cages. These preliminary experiments indicate that if *Lygus* insects occur in sufficient numbers on growing plants they will so limit the growth of the plants as to cause considerable reduction in the hay yield.

Individual cages were placed on 50 young alfalfa blossoms July 7, in preparation for experiments to determine the effect of *Lygus hesperus* on blossom drop. Blossoms on the same stems with those selected for caging and located adjacent to them were clipped off, as were also the terminal tips of the stems. On July 10, a maximum number of the individual flowers on the blossoms seemed prime for fertilization, so the cages were opened and all the mature flowers on each blossom were tripped with the point of a pair of scissors or a pencil point. Four *Lygus hesperus* were placed in each of 25 cages while insects were excluded from the other 25. Only males were placed in five cages, while both males and females were put in the other 20 cages. The cages were examined on July 19, nine days after the insects were introduced, the dead insects were counted and an estimate was made of the number of pods setting on each blossom. A similar examination was made on July 25, 16 days after the insects had been introduced, and an exact count was made of the number of pods formed. Table 2 records the data obtained.

No pods were produced in any of the cages into which *Lygus hesperus* was introduced except Cages 7, 16 and 36. Pods in these three cages might be accounted for by the fact that the insects did not feed upon the blossoms during the short time that they were in the cages or that the

TABLE 2. THE EFFECT OF *Lygus hesperus* KNIGHT ON THE DROP OF BLOSSOMS IN ALFALFA

Cage No.	Insects introduced	July 19		July 26	
		Dead insects	No. pods	Dead insects	No. pods
1	None	0	10	0	9
2	"	0	4	0	4
3	"	0	6	0	7
4	"	0	5	0	6
5	"	0	4	0	4
6	4	4	0	0	0
7	4	4	3	0	1
8	4	4	0	0	0
9	4	4	0	0	0
10	4 male	4	0	0	0
11	0	0	5	0	5
12	0	0	6	0	6
13	0	0	5	0	6
14	0	0	3	0	3
15	0	Stem broken, no pods set			
16	4	4	1	0	1
17	4	4	0	0	0
18	4	4	0	0	0
19	4	4	3	0	0
20	4 male	4	0	0	0
21	0	0	1	0	1
22	0	0	6	0	6
23	0	0	7	0	7
24	0	0	8	0	8
25	0	0	11	0	11
26	4	4	0	0	0
27	4	3	0	1	0
28	4	4	0	0	0
29	4	3	0	1	0
30	4 male	4	0	0	0
31	0	0	9	0	9
32	0	0	2	0	2
33	0	0	0	0	0
34	0	0	5	0	5
35	0	0	6	0	6
36	4	4	3	0	1
37	4	4	0	0	0
38	4	4	0	0	0
39	4	4	0	0	0
40	4 male	4	0	0	0
41	0	0	0	0	0
42	0	0	7	0	7
43	0	0	0	0	0
44	0	0	0	0	0
45	0	0	8	0	8
46	4	4	0	0	0
47	4	4	0	0	0
48	4	3	0	1	0
49	4	3	0	1	0
50	4 male	4	0	0	0

Summary:—Number of pods formed in 25 cages in which *Lygus hesperus* was introduced..... 3

Number of pods formed in 25 cages in which *Lygus hesperus* was not introduced..... 120

feeding was not sufficient to kill the blossoms or the small pods. The insects were all dead at the time of the first examination on July 19.

Pods were produced in all of the cages which did not contain insects except Cages 41, 43 and 44. It is entirely possible that the flowers in these cages were not pollinated by artificial tripping of the flowers or that they were injured in handling of the cages.

That feeding injury alone may cause blossom drop is shown by the fact that blossom drop also occurs in cages containing only males. No pods were formed in any of the cages containing males exclusively. In these cages the factor of injury by oviposition in the plant was excluded.

The data obtained in this experiment show definitely that *Lygus hesperus* may cause injury to alfalfa blossoms so that the flowers will not develop and so that seed will not be set. It has often been observed by the writers in many of the seed fields in which the populations of *Lygus hesperus* and *Lygus elisus* are high that many of the plants will fail to set seed on all or part of the flowers. The feeding of these insects on the plants will, in a measure, account for the poor set of seed which causes a considerable or total loss of seed in "poor seed years."

TABLE 3. THE EFFECT OF *Lygus hesperus* KNIGHT ON THE PODS AND SEEDS OF ALFALFA

Cage No.	Number of pods on racemes at introduction	Number of insects introduced	Condition of pods at harvest		
			No.	Punct. seeds	Unpunct. seeds
1	9	4	10	16	6
2	4	4	3	0	4
3	6	4	6	0	14
4	6	4	5	7	5
5	6	4	8	22	1
6	6	0	7	0	9
7	7	0	7	0	11
8	12	0	13	0	37
9	4	0	4	0	10
10	5	0	5	0	10

It has often been observed by the writers that *Lygus* insects "puncture" the pods of alfalfa, causing an injury very similar to that caused in beans as described by Shull (1933), and that the seeds shrivel inside the pods or that the pods will be so injured by the insects that the pods die before maturity. To get experimental data on this point 10 pod cages were placed on fertilized alfalfa blossoms. When the pods had filled out, four *Lygus hesperus* were placed in each cage except those which were used as checks. The data obtained from these cages are presented in Table 3.

In those cages into which insects were not introduced there were no shriveled or punctured seeds. In three of the five cages into which

insects had been introduced punctured seeds were obtained at harvest. The injury to the alfalfa seeds appeared on the seeds in the form of depressions, small holes or the shriveling of the seed. Most of the seeds which were injured were probably light enough that they would be blown out of machine-cleaned seed. This type of injury does not affect the market value of the cleaned seed, then, but reduces the yield.

Literature Cited

Shull, W. E. 1933. An Investigation of the *Lygus* Species which are Pests of Beans (Hemiptera, Miridae). Idaho Agr. Exp. Sta. Res. Bul. 11, May.

Sorenson, Charles J. 1932. The Tarnished Plant Bug, *Lygus pratensis* (Linn.) and the Superb Plant Bug, *Adelphocoris superbus* (Uhler) in Relation to Flower Drop in Alfalfa. Utah Acad. Sci., v. LX, p. 676.

RECENT DEVELOPMENTS IN OIL SPRAYS*

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Part I, Fundamental Laboratory Studies and Determinations

For the past three years tests have been conducted, both in field and laboratory with a new type of oil emulsion. The outstanding results achieved seem to warrant at this time a preliminary statement concerning some of its more salient features. The writers realize full well that until a much more extended investigation has been undertaken the present findings are more or less tentative, they point the way for further work and future developments.

For want of a better name the new spray oils are called "soluble-oils", but they are not to be confused with other soluble oils that have been on the market for some time past. The new oils do not form spontaneous emulsions, nor is ordinary agitation in the spray tank depended upon for complete emulsification. A "solute" is dissolved directly in the spray oil and it comprises one (or more) of a number of glycerides of higher fatty acids or other hydroxy esters of high molecular weight organic acids. Since these are soluble in oil in all proportions they form true solutions, no layering occurs, and the product will keep indefinitely without deterioration under all ordinary conditions. Furthermore since this product contains no water it is 100% insecticide, thus overcoming

*Part I, covering the fundamental laboratory studies and determinations, prepared by Hugh Knight, Consulting Entomologist, Claremont, California; Part II, covering the results of field tests on deciduous fruit insects, prepared by C. R. Cleveland, Entomologist, Standard Oil Company, Chicago, Illinois.

the more serious defects of the common mayonnaise emulsion which generally contains about 20% water and readily deteriorates.

Emulsification is effected in the spray tank, not by means of agitation alone, but by forced circulation through the pump under pressure and back to the tank. To accomplish this the soluble-oil is poured into the empty tank together with a few gallons of water (engine and pump running). This is taken by suction through the pump and returned to the tank through the over-flow by-pass. Emulsification is instantaneous and complete. The water intake is then started and the tank filled.

FIG. 6.—Drop of 80 viscosity Midcontinent oil on water. Angle 27°. Lens 1.2 mm.

After emulsification is effected only moderate agitation is required since a true emulsion is formed. The excessive agitation necessary for mechanical mixtures or quasi-emulsions, going under the name of "tank-mix", not being required. In general field practice the oil is simply poured into the spray tank at the moment the water intake is started and the ank is allowed to fill without a break in the process.

In addition to effecting the emulsification of oils in which they are dissolved, these "solutes" have the unique property of profoundly modifying certain physical characteristics of the oil itself, particularly those which are concerned with spreading, thickness of oil film deposited and rate of penetration or absorption into plant tissue.

If a drop of "white oil" (by that is meant *any spray* oil having an unsulphonated residue of 90% or over) be deposited on water, contrary to the popular notion, it will not spread, but forms a lens on the water, the thickness of this lens depending upon the angle of contact, which in turn is a function of the interfacial tension oil water. This is illustrated in Fig. 6 which shows a drop of oil of 80 viscosity and 96% unsulphonated residue, on water, the angle of contact being about 27.5° and the lens being approximately 1.2 mm thick at the center.

The angle of contact gives a rough idea of the unsulphonated residue as will be noted from the following experiment:—drops were deposited on water from the same base oil, but of different degrees of refinement, specifically 91%, 79% and 73% unsulphonated residue respectively. The first and second both formed lenses, the second being flatter (lower angle of contact) than the first, while the third spread slowly in a thick film over the water. The addition of spreader to the water does not materially affect this relationship. Thus, a drop of white oil deposited on water containing ¼ lb. to the 100 gallon of tank-mix blood-albumen spreader still remained in form of a lens, although somewhat flattened and with lower angle of contact. The same is true of Kayso at ½ lb to the 100 gallons. In neither case did the oil spread.

"Since the angle of contact oil-water is greater with highly refined white oils of 90% unsulphonated residue or over, than with less highly refined oils, white oils when applied in the form of a quick-breaking emulsion, or as tank-mix, should deposit more oil per unit area at a given concentration, than oils of less refinement. That this is actually the case is demonstrated in the following test between an oil of 106 seconds viscosity Saybolt 100 and 76% unsulphonated residue, and one of 105 viscosity and 93% unsulphonated residue. The results are given at three different concentrations as follows:

Concentration	Viscosity	Unsul. residue	Mgs. per 100 sq. in.
1%	106	76%	65
1%	105	93%	83
2%	106	76%	110
2%	105	93%	165
4%	106	76%	250
4%	105	93%	305

Determinations made by Frank F. Lindstaedt Research Chemist, Oakland, California. Through the courtesy of Balfour Guthrie Company, Ltd.

In all emulsions, which depend upon the release of free oil for their insecticidal action, this relation—oil-water, is of the greatest importance. Since free oil is applied in contact with water, this relationship determines the character or type of film deposited and also, to a great extent the amount of oil. If this relationship could be changed or modified, then the type of film and amount of oil deposited at any given concentration could be regulated.

When a small amount (one per cent or less) of any one of the solutes under consideration, is dissolved in white oil, and a drop of the oil is deposited on water, it spreads with almost explosive violence, so rapidly that the eye cannot follow it, and forms a film so tenuous as to be almost indistinguishable. Hence, it is obvious, other things being equal, that

the spreading qualities of the *oil* (not the water) have been greatly enhanced, thus giving better coverage and spreading, while the actual oil film or amount deposited is less per unit area. All the water soluble spreaders accomplish is to "spread" the continuous phase, or the emulsion as a whole,—they do not affect the spreading qualities of the oil.

The effect of the addition of glyceryl-oleate in determining oil deposit is shown in Table 1. The determinations were made with a precision sprayer on waxed glass.[1] The oil was of 68 seconds viscosity, 93% unsulphonated residue, western base. Oil deposit is expressed in terms of mgs per 100 sq. inches of surface. All applications made at 2% concentration.

TABLE 1

Application	Oil deposit
Mechanical mixture	172 mgs.
Tank mix with ¼ lb. blood-albumen spreader	168 "
Oil with ½% glyceryl-oleate	95 "
Oil with 1% " "	78 "
Oil with 1½% " "	68 "

The remarkable change in physical characteristics may be further strikingly illustrated by utilizing a modified form of the Donnan drop-pipette method of measuring surface tension, substituting distilled water as the standard and allowing a measured quantity of the same to drop from the tip of the pipette while immersed in the oil to be tested. The quantity of water used was 10 cc. and results are given for three representative oils, each showing drop number for the oil alone and with 1% glyceryl-oleate added.

TABLE 2

Oil	Viscosity	Drop No.	With 1% solute
Western	106	26	182
Western	60	38	146
Midcontinent	40	39	243

The efficiency of any oil spray depends not only upon the amount of free oil deposited per unit area, but also upon the thickness and uniformity of the oil film laid down and upon the length of time this oil remains upon the surface of the plant and in contact with the insect, or, upon the length of time it actually protects the surface from insect attack.

The addition of these solutes to spray oil results not only in the production of an uniform oil film over the entire surface of both leaf,

[1]Acknowledgment is made to Mr. Frank L. Lindstaedt, Research Chemist, Oakland, California, through whose courtesy the above determinations were made available.

twig and fruit, but also greatly extends the period during which this oil film remains actively insecticidal. Summer spray oils now in general use are all included within a viscosity range of 50–110 seconds Saybolt at 100° F. Attempts to classify these oils according to viscosity, distillation range, or to the percentage given off at a certain temperature (636° F. in California) are not satisfactory, since there is no necessary relationship between these factors and insect kill. For example we do not apply spray oils at 636° F. What we wish to ascertain is their behaviour at atmospheric temperature. Again, insects immersed in kerosene are killed in a fraction of the time it takes to kill them in the more viscous oils.[2] On this fact alone, one might conclude that kerosene was a more efficient insecticide than an oil of high viscosity.

The assumption that oils disappear from the leaf surface by evaporation is entirely gratuitous, with no foundation either in fact or experience. It can easily be disproved by the very simple expedient of applying a given oil to both plant and a sheet of glass at the same concentration and under the same conditions. Oils within the viscosity range specified will disappear from the leaf *surface as a free cuticular film*, plainly visible under the microscope, in from 5 to 12 days, depending upon temperature and viscosity. They will remain visible upon the glass plate from 6 months to a year or more, if kept away from dust.[3] Evidently evaporation at atmospheric temperature plays a very small part in oil disappearance from the surface of plants, in fact, until the kerosene cuts are reached, this factor may be disregarded as negligible.

There is another factor to be considered in this connection, that of surface tension, or rather the tension at the interface liquid-solid. Attempts were made to determine the interfacial tension of liquids applied to the surface of citrus leaves, by measuring the angle of contact, but these were abandoned owing to the great variation exhibited by the leaves themselves, both on the upper and lower surfaces of the same leaf, and on leaves of different age or stage of development. For instance, young leaves invariably showed much higher angles of contact than mature leaves, and mature leaves than old senile leaves. Hence absorption or penetration (as well as spreading and wetting) is least on young immature leaves and greatest on old senile or non-functioning leaves. This probably accounts for the accelerated drop of old citrus

[2]de Ong, E. R., Knight, Hugh, and Chamberlin, J. C. A preliminary study of Petroleum Oil as an insecticide for Citrus Trees. Hilgardia Vol. 2, No. 9.

[3]Knight, Hugh, Chamberlin, J. C., and Samuels, Chas. D. On Some limiting Factors in the use of Saturated Petroleum Oils as Insecticides. Plant Physiology Vol. 4. pg. 299–321, 1929.

leaves after spraying. Furthermore, the surface tension varies greatly on the upper and lower surfaces of citrus leaves, the tension being much *higher*, (therefore wetting more difficult and penetration less) on the *lower* surface of young leaves, and precisely the opposite on mature and old leaves. This is illustrated in Fig. 7, "left" and "right" which show

FIG. 7.—Left. Longitudinal section of young citrus leaf in water. Upper cutinized surface at left. Right. Longitudinal section of old citrus leaf in water. Upper cutinized surface at left.

longitudinal sections of citrus leaves immersed to half their length in water, the cutinized upper surface of the leaf being at the *left* in both cases. "Left" represents a section of a young leaf, "right" a section of old leaf. Note the high meniscus at left (upper or cutinized surface) in "left" and relatively little at the right, and the contrary condition at "right". On the young leaf penetration would take place more rapidly through the upper surface in spite of the fact that all of the stomata of a citrus leaf are situated on the lower surface. On the old leaf penetration would be more rapid on lower surface. Because of these variations waxed slides were substituted for citrus leaves in studying surface tensions. The wax used was a mixture of beeswax, paraffin and carnauba in equal parts.

In discussing the penetration of oil into plant tissue Ginsburg[4] assumes

[4]Ginsburg, Joseph M. Penetration of Petroleum Oils into Plant Tissue. Jour. Agr. Res. Vol. 43, No. 5.

that penetration is a function of viscosity, the rate of penetration being "indirectly proportional to the viscosity." He points out that oils having a viscosity of 160 or higher do not penetrate the upper surface of leaves, but may still penetrate the lower surface through the stomata.

Penetration is not necessarily related to viscosity, although it is, of course, true that increase in viscosity of petroleum oils is usually accompanied by increases in the angle of contact. For example the viscosity of water and of kerosene are nearly the same. Water does not

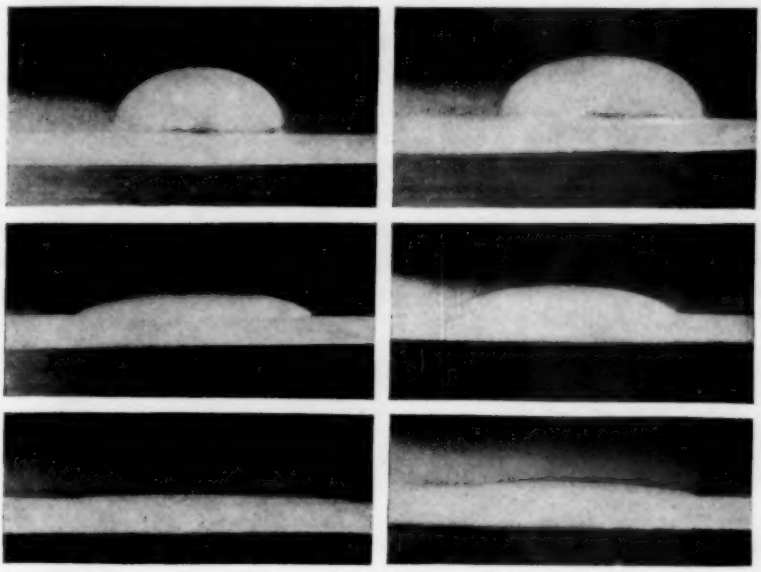

FIG. 8.—Upper left. Water. Angle 90°. Lens 3.5 mm. Upper right. Glycerin. Angle 90°. Lens 3.5 mm. Middle Left. Western Oil, viscosity 106 sec., Angle 34.5°. Lens 1.4 mm. Middle Right. Eastern oil, viscosity 68 sec., Angle 34°. Lens 1.3 mm. Lower Left. Kerosene, Western. Angle 7.0°. Lens. 0.5 mm. Lower Right. Kerosene, Eastern, Angle 13.5°. Lens 0.6 mm.

penetrate a citrus leaf at all, it gathers in drops on the surface. Kerosene, however, spreads over the surface and penetrates very rapidly indeed, disappearing in a few minutes by absorption (not by evaporation, since it remains on a glass plate for 24 hours or more). If penetration were a function of viscosity, water should penetrate at approximately the same speed as kerosene. Wilcoxon and Hartzell[5] and others have

[5]Wilcoxon, Frank, and Hartzell, Albert. Some Factors Affecting the Efficiency of Contact Insecticides I. Boyce Thompson Institute for Plant Research, Vol. 3, No. 1.

pointed out that water does not penetrate the tracheae of insects, but these workers show that by lowering the surface tension of water it may be made to penetrate, and this in spite of the fact that the viscosity may be increased when substances are dissolved in the water to lower its surface tension.

With viscosity the same and surface tension variable, surface tension is the controlling factor in penetration; with surface tension the same and viscosity variable, viscosity is the controlling factor.

If a drop of water be deposited on a waxed slide the angle of contact is seen to be 90° (Fig. 8). Now if more water be added to the drop it will become larger, but *without changing the angle of contact.* When the drop begins to spread the maximum thickness of film for the liquid being tested has been reached. Angles of contact and corresponding film thicknesses for various liquids in contact with waxed slides are listed in Table 3 and some illustrations given in Fig. 8.

TABLE 3

Liquid	Angle of contact	Film thickness
Water	90	3.5 mm.
Glycerin	90	3.5 "
Castor oil	44.5	1.8 "
Petroleum oils		
Midcontinent 140 visc.	35	1.5 "
Western 106 "	34.5	1.4 "
Eastern 68	34	1.3 "
Western 60	29.5	1.2 "
Midcontinent 40	28.5	1.0 "
Kerosene Midcontinent	13.5	0.6
Kerosene Western	7.0	0.5

The significant feature in connection with the data adduced is that all the oils tested and included within a viscosity range from 40 to 140 seconds Saybolt 100 (those oils now in general use for spraying purposes) are all embraced within a differential of 8° in the angle of contact, and approximately 0.5 mm in the thickness of film capable of being laid down. A break does not occur till the kerosene cuts are reached, when both the angle of contact and the thickness of film drop abruptly. In general the Eastern and Midcontinent oils show slightly greater angles of contact than do the Western, the difference becoming more marked as viscosity is decreased. This may account for the fact, often observed in the field, of the longer persistence of Eastern oils on the surface of plants, since a difference of a degree or two may greatly affect the rate of penetration into plant tissue.

Neither water nor glycerin will penetrate the tracheal tubes of insects. Castor oil penetrates with difficulty if at all, but from this point downward, with decreasing angle of contact, penetration increases rapidly.

The main branches of the tracheal tubes of the red scale measure approximately 3 microns in diameter. If a clean capillary tube of 0.5 mm internal diameter be drawn out to a fine thread, a section can be taken from it with an internal diameter corresponding to that of the tracheal tube of the red scale. If this be laid on a slide and a drop of water be deposited over one end it will be found to enter and traverse the tube with great velocity. If the inside of the tube be coated with wax, by dissolving a little wax in any suitable solvent and then dipping the tube into it and drying the same, on repeating the test it will be found that water will not enter. If a capillary tube of 0.5 mm internal diameter be coated with wax in the same manner, water will not enter, neither will glycerin, and castor oil only with difficulty. Glycerin is soluble in water in all proportions, but it is insoluble in oil. However, it may be rendered soluble in oil by converting it into a glyceride of a fatty acid, the glyceride carrying with it in modified form some of the properties of glycerin inasmuch as it greatly retards the penetration of spray oils when dissolved in them.

Since a very light oil penetrates plant tissue much more rapidly than a heavy one any change in rapidity of absorption would show more quickly and more distinctly with this type, so that for the purpose in view an oil of 44 sec. viscosity, 96% unsulphonated residue and a distillation range of 485°–650° F. was chosen. This oil was considerably lighter than most oils now in use commercially.

Four potted citrus plants of uniform size were chosen and each was sprayed with the same amount of material and at a concentration of 4% oil. The first plant as a control was sprayed with a quick-breaking emulsion of the straight oil, using calcium-caseinate (Kayso) as the emulsifying agent at the rate of 1 gram to 100 cc of the oil. The oil deposit was very heavy, probably twice as heavy as in the subsequent tests, yet in spite of this the oil had all disappeared from the surface as a free cuticular film in four days, while the next plant sprayed with the same oil containing 1% of glyceryl-oleate retained its oil a day longer despite the light deposit. With 2% of the solute the oil remained on the surface 13 days and with 4% of the solute 16 days.

When the amount of solute is increased above 1% the emulsion tends to become stabilized. In order to release the oil it is necessary to use a suitable "spreader."

Clayton [6] has shown that when certain electrolytes, especially those salts containing polyvalent cations, are added to an emulsion a state of unstable equilibrium results, which, if carried far enough, results in inversion. He lists them in the following order,—Al. Cr. Ni. Pb. etc.

If aluminum sulphate finely ground be added to Kayso spreader in proportion of 2% or 3% by volume and be thoroughly mixed, and this be used at the rate of ½ lb. to the 100 gallons of diluted spray, it will have the effect of releasing the oil or of preventing stabilization. The aluminum salt may be incorporated directly in the oil itself in the form of aluminum naphthenate, thus obviating the necessity of adding a "spreader" to the dilute emulsion in the spray tank. In this latter form it has the advantage of still further retarding the penetration of the oil and maintains an oil film on the surface for a greater length of time.

Spray oils of 70 to 80 seconds viscosity treated with a combination of glyceryl-oleate and aluminum-naphthenate and applied at the usual 2% concentration to citrus plants have maintained a free film of oil on the surface for a period exceeding 60 days, under laboratory conditions, where the corresponding control plants treated with the same oils at the same concentration, ceased to show free oil after 10 to 12 days.

The effect of oil release by the addition of the aluminum salt is shown in the following Table,[7] the oil used and the method being the same as in Table 1.

TABLE 4

Application	Oil deposit (mgs. pr. 100 sq. in.)
Oil with 1 % glyceryl-oleate	78 mgs.
Same plus ¼% Al-naphthenate	91 "
" " ½% "	92.5 "
" " 1 % "	95 "
" " 1½% "	107 "
" " 2 % "	114 "
" " 3 % "	143 "

During the past two years several thousand acres of citrus have been sprayed with soluble oil, containing 1% of glyceryl-oleate as the emulsifying agent and penetration retardent. The results against black and citricola scale have been outstanding. Present indications point to the possibility of successful control of red scale also, by reason of the added protection afforded by the persistent oil film in destroying the emerging young.

[6] Clayton, William. The Theory of Emulsions and their Technical Treatment, pg. 109.

[7] Determinations made by Mr. Frank L. Lindstaedt, Research Chemist, Oakland, California.

Up to the present no case of injury has been reported; in fact, due to the very light oil deposit (less than half that of of tank-mix) these soluble oils appear to be less injurious than tank-mix mechanical mixtures.

To what extent the regulation of oil penetration and the maintenance of oil films on foliage can be carried without producing injury remains to be investigated. The effects produced in the laboratory are considerably modified in the field, but these modifications are in degree only and not in kind. For instance oil penetration cannot be controlled to any great extent on old senile foliage, nor on any foliage where the protective outer coating or layer of cutin has been destroyed, whether by the work of insect pests, as in red spider injury, or by abrasion, or ordinary wear and tear. Accumulation of dust on the leaf surface either before or after application acts as an absorbent and tends to modify the time of persistence.

The use of these solutes will probably greatly enlarge the field of oil sprays as insecticides. Indications are that the application of heavy oils may be made safer, and on the other hand very light oils may be made available for use.

Part 2.—Results of Field Tests on Codling Moth and Pear Psylla

Petroleum oil preparations embodying the principles and properties outlined in Part 1 of this discussion were tested on apples and pears for control efficiency on codling moth and pear psylla and for general performance in comparison with summer oils of the conventional inert cream or mayonnaise emulsion type, and with oil-arsenical combination sprays in the summer of 1933.

These tests were conducted in two apple orchards, one in Illinois and one in Indiana; and in one pear orchard in Michigan.

Codling Moth on Apples, *Williams Orchard, Barry, Illinois.* — The oil preparations tested in this orchard were as follows:

Oil A—Technical white oil of 80–85 seconds viscosity at 100° F. approximately 96 per cent saturated, in which was dissolved 5 per cent of glyceryl-oleate.

Oil B—Technical white oil of 80–85 seconds viscosity at 100° F. approximately 96 per cent saturated, in which was dissolved 5 per cent of Aluminum Naphthenate and ½ per cent of glyceryl-naphthenate.

Oil C—The conventional summer white oil used for comparison was a mayonnaise emulsion, comprising approximately 65 per cent of the

same white oil used in Oils A and B, but not treated with glyceryl-oleate or naphthenate, or aluminum naphthenate.

SPRAY PREPARATION PROCEDURE.—Oil A possesses too high a degree of emulsibility to produce a true quick-breaking emulsion and optimum oil deposit and coverage. Hence, it was necessary to employ an electrolytic agent in the water in order to destabilize the emulsion to a point where oil deposit and coverage would be effective. The procedure was as follows:

Enough water (about 20 gallons per 200 gallon tank) to reach the agitator shaft was run in first. The engine was then started, and a single gun discharging a full force of liquid was inserted *underneath* the surface of the water, and held there continuously with pump and agitator running. The electrolytic agent employed, namely, Kayso spreader, containing 5 per cent aluminum sulphate thoroughly mixed, was sifted into the small amount of water originally run into the tank, at the rate of ½ lb. per 100 gallons. This was thoroughly mixed with the water during about 2 minutes operation of the pump and agitator. Oil A was then added slowly, with pumping and agitation continued during the addition of the oil and for another two or three minutes afterward and before more water was added. The tank was then filled with water, with agitation and pumping continued until the tank was full.

The sprayer employed in these tests was a Friend of 250 gallons capacity, giving a pressure of 275 pounds at the pump, and with an agitator speed of about 70 R.P.M.

With this machine and with the mixing procedure described above, apparently good initial emulsification of the oil was obtained, but it creamed rapidly, and dispersion of the oil throughout the mix during the spraying operation did not appear to be entirely complete. However, a reasonably successful dispersion was maintained.

Oil B was not used alone in this test, but in one plot in certain applications was used in combination with Oil A in the proportion of three parts of Oil B, to one part of Oil A. With this combination it was not necessary to use a destabilizing agent, as the aluminum naphthenate functions in that capacity, while the mix contains a sufficient amount of glyceryl-oleate to provide emulsibility. This combination of Oils A and B, therefore, was mixed in the tank in the same manner as that described for Oil A, but without the addition of the Kayso—aluminum sulphate, or any other material. Initial emulsification was apparently successful. Subsequent dispersion of the oil was apparently a little harder to maintain than with Oil A alone, although creaming was less evident. A

slight amount of free oil rose to the top of the spray mix and persisted there throughout spraying, but a fairly satisfactory uniform dispersion of the main body of the oil was maintained.

Oil C was emulsified in the customary manner, that is, by predilution and thinning with a small amount of water first, followed by pouring this thinned emulsion into the tank as it was being filled.

EXPERIMENTAL PLOTS AND TREATMENTS.—The plots were located in a section of the orchard where codling moth had been most prevalent and injurious in past years. The principal variety involved was Jonathan, although a few Grimes Golden Trees stood in each plot treated with the new oils. The trees were 15–20 years old, and bore a fairly good crop. Each plot consisted of at least 25 trees.

All plots received a standard spray of arsenate of lead (4–100) and dry lime sulphur in the calyx and for a first cover on May 23–24.

Plot 1 received a second first brood cover of Oil A at 1 per cent strength on June 3, and a third first brood cover of Oil A at 1 per cent on June 22. Observation on July 11 showed this treatment to be ineffective in worm control compared to that being produced by a standard summer oil C-calcium arsenate spray, so on July 12, plot 1 received a combination fourth cover (second brood) spray of the 3 to 1 combination of Oil B plus Oil A at 2 per cent strength.

This spray immediately checked worm attack very effectively, permitting an increase of only 4.2 per cent injury from July 11 to August 1, while the corresponding Oil C-calcium arsenate treatment permitted an increase of 12.2 per cent codling moth injury over the same period. However, observation on August 1 indicated the development of some oil burning in plot 1. Hence, it was felt advisable to reduce the amount of oil being used, so on August 2, it received an application of Oil B plus Oil A at 1 per cent strength plus nicotine sulphate at 1–1200. The final treatment on August 17 was the same as on August 1.

Plot 2 received applications of Oil A at 2 per cent strength on June 3, June 22 and July 12. Then, on account of foliage injury appearing to a significant degree, the oil was reduced, and the plot received Oil A at 1 per cent plus nicotine sulphate at 1–1200 on August 2 and on August 17.

Plot 3 received applications corresponding to plots 1 and 2, but was treated with the conventional summer oil emulsion C at 1 per cent strength plus calcium arsenate (3–100) and lime (6–100) in the first brood applications, and with Oil C at 1 per cent plus nicotine sulphate at 1–1200 in second brood sprays. For purposes of determination of results plot 3 was di-

vided into two parts, namely 3A and 3B, 3A lying adjacent to plot 1 and 3B adjacent to plot 2. The reason for this division was that plots 1 and 3A lay in a more heavily populated codling moth section than plots 2 and 3B.

Plot 4 received a standard application of arsenate of lead (4–100) and lime (8–100) in all first brood covers; calcium arsenate (3–100) lime (6–100) and oil C (1 per cent) in the first second brood cover, and Oil C (1 per cent) plus nicotine sulphate (1–1200) as a final second brood cover.

FINAL RESULTS—COUNTS SEPTEMBER 13

Plot No.	Treatment	Per cent wormy	Per cent inc. in injury since June 20
1	*1st Brood*		
	Oil A (glyceryl-oleate) at 1%		
	2nd Brood		
	1 — Oil A (glyceryl-oleate) + Oil B (aluminum naphthenate) at 2%		
	2–3 — Oil A + Oil B + Nicotine (1–1200) at 1%	23.2	17.3
3A	*1st Brood*		
	Oil C (1%) + calcium arsenate		
	2nd Brood		
	Oil C (1%) + nicotine (1–1200)	38.8	33.5
2	*1st Brood*		
	Oil A (glyceryl-oleate) at 2%		
	2nd Brood		
	1—Oil A at 2%		
	2–3—Oil A (1%) + nicotine (1–1200)	17.1	15.4
3B	*1st Brood*		
	Oil C (1%) + calcium arsenate		
	2nd Brood		
	Oil C (1%) + nicotine (1–1200)	25.4	26.6
4	*1st Brood*		
	Arsenate of lead		
	2nd Brood		
	1—Oil C (1%) + calcium arsenate		
	2 & 3 Oil C (1%) + nicotine (1–1200)	51.7	43.5

The results, as reported in the preceding table, show that an oil preparation containing glyceryl-oleate is superior to a corresponding treatment of a mayonnaise type of summer oil emulsion combined with calcium arsenate or nicotine sulphate, in controlling codling moth.

Results elsewhere indicate that a conventional summer oil at 1 per cent plus calcium arsenate is probably at least equal or superior to the same type of oil at 2 per cent strength alone or to arsenate of lead at

standard strength alone. Thus, it would appear that a glyceryl-oleate oil is undoubtedly a distinct improvement in effectiveness on codling moth over either the previous types of summer oil sprays or other previously standard materials, such as arsenate of lead alone.

The results also indicate that the incorporation of aluminum naphthenate improves the effectiveness of the oil containing only glyceryl-oleate. The plot treated with a combination of aluminum naphthenate and glyceryl-oleate showed a 15.6 per cent better control than the corresponding plot treated with ordinary summer oil plus calcium arsenate, while the glyceryl-oleate plot shows only 8.3 per cent better control than the corresponding oil-calcium arsenate plot.

Plot 1 showed over twice as much codling moth injury on July 11 (due to using only 1 per cent of Oil A and to a less favored location) as plot 2; but after Oil B (aluminum naphthenate) was combined with Oil A in plot 1, this treatment shows a definite checking of injury so that at harvest it has only 6.1 per cent more injury than the glyceryl-oleate oil.

Oil Deposit and Coverage.—The oil A-Oil B combination produced a more pronounced oil deposit on leaves and fruit than Oil A alone. Both oils formed an even, uniform film coverage, in contrast to the blotchy or drop type coverage produced by Oil C.

Effects on Foliage and Fruit.—No positive oil spray injury followed the treatment of June 3 in the case of either oil. A light to moderate marginal leaf burn resulted from the June 22 application of Oil A (2 per cent glyceryl-oleate). A trace of the same type of injury developed from the June 22 application of Oil A at 1 per cent.

Additional leaf burning followed the July 12 application of Oil A (2 per cent) and also of Oil A and B (2 per cent). Several weak Grimes trees in plot 2, Oil A (2 per cent) showed severe burning. All trees in both plots showed some burning by August 1. Several of the weaker trees in plot 1, Oil A-B (2 per cent) on July 12, showed moderate burning on August 1.

After changing to 1 per cent of both Oils A and Oils B plus A, plus nicotine for the last two sprays, little or no additional burning appeared.

No injury or other objectionable effects, were produced on the fruit by either oil combination. Even Grimes, that is very susceptible to spotting by the mayonnaise type of oil emulsions, showed no such effect from these new oils.

Davis Orchard—Plainfield, Indiana.—The oils used in this experiment were as follows:

Oil A—The same 80–85 viscosity technical white oil as that used in the Williams orchard, containing a 5 per cent solution of aluminum naphthenate (3 parts) and glyceryl-oleate (1 part). This is virtually the same preparation as the combination of Oils A and B in the Williams test, except that no glyceryl naphthenate was incorporated in Oil A of the Davis test.

Oil B—The technical white oil as in Oil A, containing 5 per cent of aluminum naphthenate plus ½ per cent of glyceryl-naphthenate in solution.

Oil C—The same commercial brand of a conventional mayonnaise type summer oil emulsion as Oil C of the Williams test.

Spray Preparation Procedure.—Oil A was emulsified in the same way as that employed for the combination of Oils A and B in the Williams orchard. Emulsification and dispersion were quite satisfactory.

Oil B was emulsified by first mixing one pound of Kayso spreader per 100 gallons in a small amount of water in the tank, under pressure and agitation. The oil was then added slowly with pumping, agitation and filling procedure the same as for Oil A. Emulsification and dispersion were fairly satisfactory, but apparently not quite as complete as with Oil A.

The equipment used was a Bean sprayer, 200 gallon capacity, 350 pounds pressure at the pump, with agitator speed of approximately 90 R.P.M.

Experimental Plots and Treatments.—All plots were sprayed alike in all first brood applications, receiving a calyx and first cover of arsenate of lead and lime sulphur, and a second cover of conventional type summer oil at 2 per cent strength on about June 1..

Experimental treatments were begun on July 4–6, this being the first second brood spray.

On this date, treatments were as follows:

Plot 1—Oil A at 2 per cent—variety, Winter banana.

Plot 2—Oil B at 2 per cent—variety, Senator.

Plot 3—Oil B at 1 per cent—variety, Senator.

Plot 4A—Oil C at 2 per cent—variety, Winter Banana.

Plot 4B—Oil C at 2 per cent—variety, Senator.

Check—unsprayed—variety, Winter Banana.

The above treatments were repeated on August 24, and there were no other spray applications on any of the plots at any time.

The long interval elapsing between sprays was due to the fact that prior to 1933 this orchard had been relatively free of codling moth

attack. A small degree of worm injury was evident in all plots on July 6, and a second observation on July 28, showed only a very slight increase, leading to the belief that one second brood application might suffice.

However, a third observation on August 21 showed that moth attack had increased greatly between July 28 and the latter date. Hence, to provide protection during the balance of the season, another application of the experimental treatments was made on August 24.

FINAL RESULTS—HARVEST COUNTS

Winter Banana—September 12

Plot No.	Treatment	Total % moth injury	% Increase in injury since Aug. 21
1	Oil A (Aluminum Napthenate & glyceryl-oleate) 2%	42.8	12.0
4A	Oil C (Conventional Summer Oil) 2%	51.6	19.1
Check	Unsprayed	65.2	26.2
	Senator—September 18		
2	Oil B (aluminum napthenate) 2%	10.0	0.0
3	Oil B (aluminum napthenate) 1%	19.8	3.5
4B	Oil C (conventional summer oil) 2%	26.6	5.6

DISCUSSION.—On account of the high percentage of stings shown by some of the plots, it was felt that a record of the total moth injury (entrances plus stings) would give a more significant and accurate picture of the relative efficiency of the different treatments than a record of entrances alone.

The increase of injury from August 21 to harvest is indicated, and gives a more accurate evaluation of the comparative performance of the several treatments, since the final results on all plots were vitiated to a marked degree obviously by the greatly prolonged period from July 6 to August 24, during the latter part of which at least there was little or no protection against attack.

EFFECTS ON FOLIAGE AND FRUIT.—Foliage burning on all plots followed the July 6 spray. One tree in plot 1, Oil A, showed severe burning. The balance of this plot was only slightly burned.

Plot 2, Oil B at 2 per cent, showed severe burning on several trees, and moderate burning throughout.

Plot 3, Oil B at 1 per cent, showed slight burning throughout.

Plot 4, Oil C at 2 per cent showed severe burning on some trees, and moderate to slight burning throughout.

The general severity of burning was worst on Plot 2, next worst on Plot 4, and least on Plots 1 and 3.

There was no noticeable additional burning on any of the plots following the August 24 spray.

No other effects, such as yellowing or defoliation, were apparent as direct result of the oil applications. In fact, at harvest, the check or unsprayed plot was noticeably more severely defoliated than any of the sprayed plots.

OIL PERSISTENCE.—On September 12, the apples in Plot 1, Oil A, were still noticeably oily or greasy, showing an even film coverage, while the apples in plot 4A, Oil C showed some waxlike spots, but general oil film coverage much less apparent than on Plot 1.

On September 18, Plot 2, Oil B (2 per cent), showed a marked oily even film coverage on the fruit; Plot 3, Oil B, (1 per cent) less, and plot 4B, Oil C (2 per cent) only a slight trace of grease-like spot coverage.

PEAR PSYLLA EXPERIMENTS, *Vesper Orchard—Fenville, Michigan.*—Variety—Howells, selected because of unusual susceptibility to psylla attack.

A strong infestation of psylla developed in this orchard early in the season. On June 26, adults were abundant and were laying eggs actively. First instar nymphs were beginning to appear.

It was felt that the pear psylla should provide an unusually good subject for a test of the distinctive properties of the new oils, namely even uniform film coverage, strong oil deposit and long time surface persistence.

The oils used were as follows:

Oil A—The same technical white oil used in the apple tests, containing 5 per cent glyceryl-oleate in solution.

Oil B—Technical white oil, containing 5 per cent aluminum naphthenate plus ½ per cent glyceryl naphthenate.

Oil C—Conventional mayonnaise type white summer oil emulsion.

SPRAY PREPARATION PROCEDURE.—The same methods of emulsification and mixing were employed as in the apple tests.

The water used was very hard and the spray equipment less efficient than that available on the Williams and Davis orchards. Consequently emulsification and dispersion were somewhat less satisfactory than in the apple experiments. It was workable, but it was difficult to keep the oils satisfactorily dispersed throughout the spraying process.

EXPERIMENTAL PLOTS AND TREATMENTS.—Each plot consisted of about 35 trees, being five rows wide and seven rows in length.

Plot 1 received an application of Oil A at 2 per cent on June 26 and on August 9.

Plot 2 received an application of Oil B at 2 per cent on June 27 and on August 21. The reason for deferring the second application on this plot until August 21 was because of the virtual absence of any infestation or injury on August 9, and it was desired to learn how long the June 27 spray would continue to give protection.

Plot 3 received an application of Oil C at 2 per cent on June 28, and was so severely infested and injured on August 8 that a spray of Oil A (1 part) and Oil B (3 parts) at 2 per cent was applied on August 9 to determine what this combination might accomplish in cleaning up the infestation and preventing further attack.

Plot 4 received a commercial spray of Oil C at 2 per cent on June 28, and no additional applications, since the owner felt that it was so severely injured at that time and the crop was so light that respraying would not be a profitable investment.

RESULTS.—The most significant results, and those showing most accurately the true comparative efficiency of the several oils tested, were observed on August 8, approximately 43 days following the initial spray application.

Results were recorded mainly in terms of the degree of leaf infestation, with the general condition of the fruit noted and are shown in the following table:

Plot No.	Treatment	Per cent heavily infested	Per cent lightly infested	Per cent clean	Fruit
1	Oil A (glyceryl-oleate) 2%	23.2	45.5	31.3	Nearly clean
2	Oil B (aluminum napthenate) 2%	0.3	10.8	89.9	Clean
3-4	Oil C (conventional summer emulsion) 2%	49.6	47.6	2.8	Severely marked

FINAL RESULTS—HARVEST COUNT, SEPTEMBER 7.—Results of this observation were recorded in terms of the degree of soiling due to honey dew accumulation by psylla shown on the fruit. A record of codling moth injury was also taken.

Plot No.	Treatment	Per cent clean	Per cent light injury	Per cent moderate injury	Per cent severe injury	Per cent codling moth
1	Oil A (2%) 6/26 and 8/9	85.0	15.0	0.0	0.0	5.2
2	Oil B (2%) 6/27 and 8/21	53.93	37.07	9.0	0.0	7.4
3	Oil C (2%)—6/28. Oil A + Oil B (2%) 8/9	12.0	44.8	38.0	5.2	12.0
4	Oil C (2%) 6/28	0.4	2.4	26.4	70.8	18.0

There was a very heavy active psylla infestation on plot 4 on September 7, as shown by the presence of numbers of living nymphs and adults on the leaves and by copious quantities of fresh honey dew on both leaves and fruit. On all the other plots there was little or no fresh honey dew and few living psylla nymphs or adults. Such injury as appeared on these plots was in the form of old blackened honey dew residue produced prior to the sprays of August 8 and August 21.

The reversal of results between plots 1 and 2 showing on September 7 as compared to August 8 was due to having plot 2 unprotected too long between August 8 and 21 and not to inferiority of Oil B.

SPRAY INJURY.—There was no certain indication of oil injury on any of the plots. Dropping and browning of leaves that occurred was characteristic of psylla attack, not of oil injury.

Some leaf yellowing was evident on all plots, and was especially noticeable on plot 2, Oil B (aluminum naphthenate). This symptom may have been associated with some effect from the oil, but this is not conclusive from the evidence observed.

CONCLUSIONS

1—New developments in petroleum oil sprays involving the incorporation of certain oil soluble substances of the higher fatty acid glycerides or other hydroxy esters of high molecular weight organic acid type and certain salts containing polyvalent cations, show decided effects in so altering the physical properties of the oils treated as to influence viscosity, interfacial tension oil—solid, drop size, film thickness and possibly additional characteristics. This results in retardation of oil penetration into leaf and fruit tissues, thus increasing surface persistence, and improving the effectiveness and lasting properties of the oils so treated against certain insects.

2—In addition to such effects, certain of these compounds serve as efficient internal oil-soluble emulsifiers.

3—Field tests on codling moth and pear psylla corroborate the theoretical asumption of the insecticidal significance of the properties enumerated, and show that the influence exerted by the solutes described is beneficial in materially improving the effectiveness of oils against both these insects.

4—Of the specific substances tested, aluminum naphthenate thus far appears to affect oil viscosity and persistence most profoundly, and to be most effective in providing improved protection against codling moth and pear psylla attack.

5—Both glyceryl-oleate and aluminum naphthenate contribute valuable improvement effects to petroleum oils, producing preparations that are plainly superior to the former conventional types of summer oil emulsions in insecticidal efficiency.

6—The new oils offer promise of improvement over the insecticidal efficiency of other types of insecticides now in standard usage as well.

7—These new oil preparations appear reasonably safe for use on citrus and deciduous fruits, but require additional investigation to verify and possibly to improve that factor.

8. Further study is required to perfect these oils for practical commercial usage from an emulsification and dispersion standpoint under the spray equipment and practice conditions of some sections.

Scientific Notes

A Method for Shipping Mosquito Eggs.—In connection with experimental work being conducted by the Bureau of Entomology of the United States Department of Agriculture in Washington, D. C., there arose, during the fall and winter of 1932–33, the need of a continuous supply of larvae of *Culex quinquefasciatus* Say, a widely distributed species which had been used in tests conducted during the summer. After necessary arrangements regarding interstate shipments of living insects had been made, the writer, who was located in central Florida where these mosquitoes are active throughout the year, was requested to supply this need. Preliminary shipments of eggs and of larvae were made to ascertain which stage would better stand the shipping. It was found that while it was possible to ship the larvae in water in leak-proof bottles and have numbers of them arrive at destination in good condition, the better method was to ship the egg rafts and rear the larvae in Washington.

The egg rafts were collected daily from water receptables maintained in the laboratory yard at Orlando, Fla., to attract oviposition. For shipping, ordinary cardboard pill boxes having a diameter of 1½ inches were used. A box of this size easily accommodated from 100 to 125 egg rafts. Each box was prepared for this purpose by placing a layer of absorbent cotton in the bottom and covering this with a tight-fitting disc of blotting paper; a disc of blotting paper was also placed in the lid. For use, a box thus prepared was partly filled with clear water and the egg rafts transferred from the oviposition receptacles to it by means of a wire loop. The free water in the box was then pipetted out, a disc of damp gauze placed over the eggs, and the cover put on. The box was next wrapped in waxed paper and placed in a pill box of the next larger size, then wrapped in strong paper, sealed, and mailed in a letter envelope to Washington, where it arrived on the morning of the second day following. Upon arrival, the eggs were floated out of the box onto water in breeding jars, where hatching promptly occurred.

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Catalase Content and Mortality of Insects Exposed to Lethal Temperatures. It is a matter of common observation that insects when exposed to high temperatures become very active at first and then gradually become dormant and appear to be dead. If such insects are removed to a cool place before a certain point is reached, they will revive. It was thought that possibly activation of the enzymes by a rise in temperature produced the increased activity and that inactivation of the enzymes by continued heating eventually brought about the dormant state which preceded death. It was further thought that the insects would revive unless the point had been reached when complete inactivation of the enzymes had taken place.

With the object of ascertaining the possibility of such a relationship, an experiment was conducted using adults of the confused flour beetle, *Tribolium confusum*. They were held at a temperature of 118°F. for 10 hours. None of the check insects revived after the sixth hour. Ten catalase determinations were made at hourly intervals. No relationship was found between catalase content and mortality. The results showed that a gradual inactivation of the enzyme was brought about but no abrupt change took place in this general trend even after 100% mortality had been produced.

J. H. PEPPER, *Assistant Entomologist, Montana Agricultural Experiment Station*

Starved Horn-worm Larvae Make Excellent Laboratory Material. In a somewhat preliminary test conducted under controlled conditions, it was found that starving some insect larvae rendered them vastly more desirable as laboratory specimens for the examination of internal structures than the unstarved larvae. Fully grown actively feeding larvae were placed in a temperature control chamber at about 17°C. without food. Ten larvae were removed each day for 8 days and injected with a preservative composed of 120 cc. water, 15 cc. alcohol and 7 cc. formaldehyde. They were then placed in an air-tight jar containing the same preservative. At the end of about three months, the larvae were examined and it was found that, compared with larvae injected without starving, the larvae starved six days were found to have very little fat left within the haemocoele and that the visceral organs were fully exposed. After the sixth day no improvement in the condition of the larvae was observed. Tobacco horn-worm larvae were used in this experiment. Larvae prepared in this manner proved very satisfactory for class work.

E. M. SEARLS, *Madison, Wis.*

A New Pest in Tobacco Plant Beds, *Limnobia ultima* O.S. In April 1932 possibly a dozen farmers near Clarksville, Tenn., reported that some unknown larva, later determined by C. T. Greene as being of the tipulid fly, *Limnobia ultima* O. S., was destroying tobacco plant beds. Investigation showed that a dipterous larva was present in large numbers and that these larvae were beginning to cause considerable damage to the small tobacco seedlings. It was not noted that these larvae actually ate any part of the tobacco plants, but the injury was caused by their working in the soil near the surface, leaving finely divided soil particles about the plants. This condition resulted in an excessive aeration with a consequent heavy evaporation of soil moisture. The tobacco plants, being very short-rooted at this stage of growth, wilted and died from lack of moisture. Losses were not over 5 to 10 per cent in any

of the beds examined. However, the damage might have been much greater had not frequent rains at this time kept the top soil compacted and moist, until the seedlings were able to establish deeper root systems.

Tests were made with potassium permanganate, 4 grams per gallon of water (freshly mixed), and with nicotine sulphate, 10 cc. per gallon of water. The beds were drenched with these solutions and in each case effective control of the infestation was obtained. Kills of the larvae were noted within a very few minutes after the soil had been treated.

J. U. GILMORE and JOE MILAM, *U. S. Department of Agriculture, Bureau of Entomology*

Will Fluorine Compounds be Accepted as Insecticides? Experimental data secured at the Ohio and Wisconsin Agricultural Experiment Stations show that Fluorine is an extremely toxic and dangerous poison when fed to animals. The teeth and bones are so affected that when complete data is published a psychological reaction is certain to arise against the use of any fruits or vegetables sprayed with Fluorine compounds.

A report of the results secured at the Ohio Experiment Station was published in the *Jour. Agr. Res.* 46 (1933) No. 11, pp. 1023–1037. At Wisconsin this work is being carried on jointly between the Departments of Animal Husbandry, Agricultural Chemistry, and Poultry Husbandry, and includes a series of feeding tests with rats, chickens, pigs and cattle. The original purpose of the experiment was to determine to what extent rock phosphate might be used in place of bone meal in animal rations. The fluorine content of the rock phosphate is quite high and at the lower levels of substitution have produced a serious toxic effect.

The early results were published in Bull. 421 of this Station, which is the Annual Report of the Director for 1930–1931, pp. 104–107. Further publication has been made in the November, 1933, issue of the *American Journal of Physiology*, under the title of "Studies on Fluorine in the Nutrition of the Rat."

Those who are interested in the use of fluorine compounds for spraying or dusting will find these papers interesting and may be prepared for new data, yet unpublished, which shows conclusively that fluorine is extremely dangerous in amounts near the tolerance now allowed. Even the entomologist who sees the effect of decayed teeth and over-developed bones of the experimental animals is likely to be reluctant to risk food sprayed with fluorine compounds.

H. F. WILSON, *Madison, Wis.*

Experiments with Kerosene Against Apple Maggot Pupae. During the course of experimental work with the apple curculio (*Tachypterellus quadrigibbus* Say) it was found that a large proportion of the beetles were killed with kerosene emulsions at various concentrations. In order to test the effect of the emulsions on the apple maggot (*Rhagoletis pomonella* Walsh) an experiment was carried on in the following manner: In the autumn of 1932 seven areas of sod ground, 4x6 ft., were artificially infested with apple maggots by placing an even layer of heavily infested apples over the ground. As the maggots emerged from the fruits they entered the soil. In the spring of 1933 each of the infested areas was divided into two equal parts, giving a total of 14 areas. One half of the areas was treated, while the other half served as controls. The materials used for the treatments were kerosene emulsions of different strengths and kerosene emulsions in combination with paradichlorobenzene and naphthalene. The two latter were incorporated into the emulsions by first dissolving

them in kerosene until a saturated solution was obtained. A finely divided clay served as the emulsifying agent, it being used at the rate of 1 lb. per gallon of kerosene. The emulsions were applied with a knapsack sprayer at the rate of 1 qt. per square foot of surface, taking care to get an even distribution. The application was made on June 16. Twenty-four hours later a cheese cloth cage was placed over each area. A daily record was taken of the fly emergence. The first flies appeared on June 24. The following table summarizes the results obtained from this experiment.

Treatment	No. flies from untreated area	No. flies from treated area	Per cent kill over control
50% kerosene	73	0	100
25% kerosene	139	0	100
50% kerosene and Naph	296	0	100
50% kerosene and P. D. B	462	0	100
10% kerosene and P. D. B	237	4	98.3
25% kerosene and Naph	287	7	97.6
10% kerosene	161	7	95.7

O. H. HAMMER, *Assistant in Research, N. Y. Agr. Exp. Sta., Geneva, N. Y.*

A Suggestion for an Improved Method of Spraying for the Small Home Owner.[1] It is the writer's belief that many home owners who have a few trees, shrubs, or other plants, would apply control measures for various common insect pests if proper equipment were available to do a satisfactory job of spraying. In the majority of cases the amount of insect control work to be done is too small to be handled reasonably by the large commercial spray companies, and the home owner, should he desire to spray, has little equipment with which to do the job. Many possess hand sprayers, but these are of little value for even small trees. A few may own a knapsack sprayer or a bucket pump. These outfits, however, usually develop a low pressure, have inadequate agitation, and are laborious to operate. At best, the job of spraying even a 10-foot tree is difficult and the results are often unsatisfactory.

In connection with work with repellents at the Japanese Beetle Laboratory during 1930, a power sprayer especially adapted for applying small quantities of material was required. As no satisfactory commercial type of machine was available at that time, one was devised by A. R. Whitcraft and the writer, and is described in the Journal of Economic Entomology (A Power Spray Outfit Adapted for Applying Small Quantities of Material. F. W. Metzger and A. R. Whitcraft. Jour. Econ. Ent., Vol. 24, No. 3, pp. 754–758, illus. June, 1931).

This outfit was comparatively cheap, inexpensive to operate, and easy to handle. Since that time, similar sprayers on light carriages occupying little space and operated by electricity have been developed for greenhouse spraying. These could easily be adapted for outdoor use.

Such a sprayer is too expensive for the average home owner to purchase and cooperative ownerships are often difficult. The thought occurred to the writer, however, that such an outfit might be purchased by dealers handling insecticides, for example, and rented out to prospective users. It appears that the demand for such equipment might at least equal that for floor waxers, scrapers, and the like, which are handled in a similar manner. If the matter were given proper publicity it is quite possible that many people would desire to use such a sprayer; or the owner of the machine might in many cases do the spraying himself, with an additional profit, in either event, from selling the necessary insecticides.

F. W. METZGER, *U. S. Department of Agriculture, Bureau of Entomology*

[1]Contribution No. 118 from the Japanese Beetle Laboratory, Moorestown, N. J.

Experiments with Rotenone and Derris to Repel the Japanese Beetle (*Popillia japonica* Newm.). During the season of 1932 it was found that the application of five sprays, each of 1 pound of 90 per cent rotenone to 500 gallons of water, appreciably reduced the number of Japanese beetles on peach and apple trees; less concentrated sprays were less effective. In view of the high cost of the rotenone it was decided to test in 1933, in addition to rotenone, a sample of derris root (air-floated derris) of known rotenone content, both alone and in combination with a summer oil.

The following sprays, containing 100 gallons of water, 0.1 pound and 0.2 pound of rotenone, 0.1 pound and 0.2 pound of rotenone plus 0.4 gallon of summer oil, 2.5 pounds and 5 pounds of derris root (4 per cent rotenone), and 2.5 pounds and 5 pounds of derris root (4 per cent rotenone) plus 0.4 gallon of summer oil, were applied to the following varieties of fruit trees: Apple—Henry Clay, Star, Wealthy, Stayman Winesap, Yellow Transparent, and Williams Early Red; peach—Hale and Elberta. The sprays were applied at weekly intervals, except that additional sprays were applied immediately after heavy rains. In no case were more than six applications made.

It soon became evident that the unsprayed trees were being attacked and that all the sprayed trees were showing evidence of repellency to the Japanese beetle. As the beetle population increased, the check trees were defoliated rapidly and some evidence of feeding could be seen on the trees sprayed with rotenone, both alone and with oil. Only a few beetles were on trees sprayed with derris alone and with derris and oil.

The results may be summarized as follows: Derris was more repellent to the Japanese beetle than rotenone, rotenone with oil was more repellent than rotenone alone, derris alone was better than rotenone and oil, while derris and oil gave the best results.

M. R. Osburn, *U. S. Department of Agriculture, Bureau of Entomology*

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

FEBRUARY 1934

The editors will thankfully receive news matter and other items likely to be of interest to our readers. Papers will be published as far as possible in the order of reception, except that papers of reasonable length may be accepted in the discretion of the editor for early publication at $3.00 per page. There is a charge of $3.00 per page for all matter in excess of six printed pages, a part page counting as a full page, this limit not including acceptable illustrations. Photo-engravings may be obtained by authors at cost.

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A. A. A. S. Winter meetings, 1934-1935, Pittsburg; December 1935, St. Louis; Summer meetings, 1934, Berkeley, June 18-23; 1935, Minneapolis.

The extremely cold weather the last of December and the even lower temperatures in early February along the Atlantic Seaboard provide an exceptional opportunity for ascertaining the effects of these extremes upon insect life. It is suggested that many entomologists will find it advisable to make observations in relation to this within the next few months.

The Boston meeting was well attended and as usual in the larger centers, the program was crowded. There were so many papers that discussion was necessarily reduced to a minimum, in spite of the fact that on Thursday afternoon there were two parallel sessions of the Association, the papers in each relating to somewhat distinct topics. This division was reasonably satisfactory and made it possible to complete the session in two days. The suggestion of a year ago and the request last fall by the Secretary for really informative abstracts did not meet with general response. There is a suspicion that some of the authors were unable, at the time of sending in the titles, to do more than formulate in very broad terms the subject matter they desired to present. It is feared that the preparation of papers is left until the last minute, and while they contain much of value, better results could be secured if more time was given to the matter. One way of greatly reducing the number of papers presented at a meeting and possibly improving their quality would be to require the completed

paper in form for delivery to be submitted to the Secretary prior to the publishing of the program. This is probably impracticable. A committee appointed to cooperate with the Secretary may be able to work out a more satisfactory program, though obvious limitations in various directions make this most difficult.

The symposium on the codling moth dealt with a serious problem not only from the purely entomological aspects, but also discussed the difficulties of cleaning sprayed fruit and safeguarding public health. There is keen interest in discovering safer spray materials than those in use, and in this connection it is well to recognize the fact that some of the materials supposedly innocuous, or nearly so, may change within plants to really dangerous compounds. It is coming to be recognized more and more that applied entomology cannot limit itself to the insect and its control. Consideration must be given to other aspects, and the symposium is noteworthy because of the reasonably complete picture presented. Owing to the need of information along these lines and the influence this is likely to exert on the spraying of the coming season, the symposium is printed in full in this issue.

It has been decided to omit the publication of abstracts in the JOURNAL and to send with the proof forwarded to each author a blank with the request that the author prepare an abstract which will meet as closely as possible the requirements of Biological Abstracts. This is to be returned to the Editor, he will complete the reference after the number has been paged, and forward it to Biological Abstracts. It is hoped that this will result in more comprehensive and satisfactory abstracts written by authors, the men who should know more than anybody else what the papers actually contain.

The proposed reduction of $230,000 for the Bureau of Entomology in the current Appropriation Bill is serious, especially after the very material cuts of last year. The latter were absorbed largely by maintenance funds. The proposed reduction means a serious curtailment in personnel. The need for economy in Federal expenditures is recognized. There is such a thing as unwise economy, and it is felt that some of these proposed reductions, notably the decrease in the appropriation for research upon fruit tree insects, the elimination of the relatively very small item for research on shade tree insects, the omission of any appropriation for research upon European corn borer, and the reduction in the appropriation for research upon bees, are at least open to question. The extremely serious situation in respect to insecticides for the control of the codling moth justifies an increase rather than a decrease in the funds available for the study of fruit insects. The elimination of the

entire item for research upon shade tree insects implies that shade trees are of little or no consequence, and the abandonment of research on the European corn borer suggests that investigations of this character have no practical value. Dr. Phillips has appeared before the subcommittee on agricultural appropriations in favor of the above mentioned items. The conditions are such that those in Federal employ are unable to speak for themselves. The economic entomologists throughout the country know full well the importance of well planned, continuous research upon problems connected with the control of the many injurious insects and realize fully that new problems and new pests are continually developing. They, better than others, are able to pass upon the value of this important governmental function, and it is suggested that they put on record their opinions in places and with individuals where such opinions count. It may be added that the Special Committee, consisting of Messrs. Britton, Cory, Felt, Houser and Phillips, appointed by President Hinds last year to do what was possible toward conserving the essential entomological activities of the Federal Bureau and which was discharged at the recent annual meeting, has been reappointed by President Phillips to do what is possible toward mitigating what are believed to be drastic and unwise reductions in funds for entomological research. This committee welcomes the cooperation of entomologists throughout the country in the attainment of this end. The State of Massachusetts abandoned its gipsy moth work in 1900 only to find five years later that much of the good accomplished had been lost, and the undertaking was then renewed on a more extensive scale. A reduction at this time in research funds available for the study of insect pests can hardly be regarded as other than retrogressive and jeopardizing the material interests of the entire country.

Obituaries

ARGYLE B. PROPER

ARGYLE B. PROPER, an associate member of the American Association of Economic Entomologists, died at his home in Wakefield, Mass., on December 16, 1933, after being ill about a week with pneumonia. Mr. Proper was born in Sunapee, N. H., on March 4, 1905. He received a B.S. degree from the University of New Hampshire in 1926 and a M.S. degree from the same institution the following year, having majored in entomology. On July 1, 1927, he was appointed a Junior Entomologist in the U. S. Bureau of Entomology for work at the Bureau's labora-

tory at Melrose Highlands, Mass., with which station he was connected up to the time of his death.

Although Mr. Proper had published but one entomological article, another manuscript had been accepted for publication and he was to have presented a paper at the Boston, Mass., 1933 meeting of the Entomological Society of America. At the time of his death he was preparing two other manuscripts. These and the papers he had completed had to do directly or indirectly with forest and shade tree insects.

Mr. Proper was a member of the Cambridge Entomological Club, at the meetings of which he was a regular attendant. Collecting insects in the White Mountains interested him and he spent much of his vacation time on hiking trips in that region. Among his hobbies were amateur radio and stamp collecting. Possessing a keen mind, a disposition to inquire and reason, and a desire to do conscientious work, the passing of this young man came at a time when he stood on the threshold of what promised to be a bright future in his chosen field.

His wife, Florence Proper, three young children, Stanton, Richard, and David, and his mother, Mrs. Imogene Proper of Melvin Hills, N. H., survive him. One can but attempt to realize how much joy and pride would have come to them and to him had this good citizen, faithful son, husband, and father been spared to round out life's usual span.

T. H. JONES

ROBERT EMERSON WALL

1903–1933

ROBERT EMERSON WALL, son of John T. and Anna Emerson Wall, was born at Neodesha, Kansas, January 20, 1903. He was graduated from the Centennial High School in Pueblo, Colorado, in 1920, and was granted a state college fellowship. In 1924 he received the B.S. degree in entomology at the Colorado Agricultural College. Immediately following graduation, he worked as a field assistant for Dr. C. P. Gillette but soon accepted a teaching fellowship at the University of Minnesota where he remained from 1924 to 1926. During this period he earned the M.S. degree. His duties at the University of Minnesota included laboratory instruction in general entomology and general zoology, the teaching of secondary school biology, as well as insect investigations for the Agricultural Experiment Station.

From 1926 to 1928 he served as instructor at Lingnan University, Canton, China. Here he taught general zoology, genetics, vertebrate zoology, and also carried out some insect investigations suggested by

the College of Agriculture of that institution. In 1928 he returned to the University of Minnesota to continue his graduate studies and was granted the Ph.D. degree in 1930. His doctor's thesis dealing with the color variations in the melon aphis was published in the Annals of the American Entomological Society a short time after his death.

In January, 1931, Dr. Wall was appointed assistant entomologist at the Montana Agricultural Experiment Station and held this position until he died. In this short period of time he made fine progress in the study of the Phalaenid moths and the insect transmission of bean mosaic, these being the two main projects in his charge. He was well fitted by both training and disposition for this type of work. One of his prominent characteristics was an honest skepticism toward the many often-neglected details in experimental procedure. In his general character and make-up he possessed an integrity of mind and purpose which was often startling if not sometimes confounding to new associates.

Dr. Wall was an ardent naturalist and took great delight in such outdoor activities as hiking, skiing, and hunting, on which trips he never failed to pick up interesting bits of natural history. Of all sports he liked big game hunting by far the most and was indeed very successful at it.

He became ill in April, 1933, but continued to work until the early part of June. On June 12 he went to the Mayo Clinic for consultation, after which he was taken to his wife's home in Eveleth, Minnesota, where he died July 29. He is survived by his wife, Nancy Welsh Wall, his baby daughter, Dorothy, and his mother, Mrs. Anna E. Wall.

His death at the very beginning of a promising career is a real loss to American entomology.

A. L. STRAND

Book Review

Termites and Termite Control, Editorial Board CHARLES A. KOFOID, S. F. LIGHT, A. C. HORNER, MERLE RANDALL, W. B. HERMS and EARL E. BOWE, pages i–xxv, 1–734, text figures 181, University of California Press, Berkeley, 1934.

This unusual book is a report to the Termite Investigations Committee set up early in 1928 under the direction of a Board of Directors, representing the important educational and industrial agencies interested in the termite problem. The purpose of this volume may be tersely summarized as a discussion of the biology of termites and an account of the termites of the United States, Mexico, the Canal Zone, the West Indies, Hawaii and the Philippine Islands, with recommendations for prevention and

control of termite damage by methods of construction and the use of chemically treated and unpalatable woods.

This work summarizes a series of cognate investigations by experts to determine the species of white ants or termites of importance in different parts of the world and to ascertain such facts about their structure and biology as may be of service in controlling these widely distributed pests in their varied habitats. The first part deals with termites and their biology, the latter being given the greater emphasis because of its practical bearing upon control methods. For practical purposes a division is made upon habits and the insects discussed under the general terms dry-wood termites and damp-wood termites. PART TWO deals in chemical investigations and presents the results of tests with a variety of proprietary compounds as well as a number of other materials, such as paints, poison dusts, fumigation and ground treatments. PART THREE gives the results of extended tests in various parts of the world with different woods and building materials. PART FOUR is a detailed and practical consideration of the prevention and repair of termite damage and methods of inspection, and contains chapters on buildings, power, telephone and telegraph lines, railroad structures, lumber storage piles and legislative action in relation to these insects. There is also a well selected bibliography. A detailed table of contents provides ready access to the various subjects considered in the volume. The reviewer regrets the absence of an index.

This volume differs from many entomological studies in its breadth, it presenting the results of investigations by biologists and entomologists, and also the studies of chemical, structural and railroad engineers. It brings within the compass of one volume our present knowledge in relation to termites and their control and is therefore a book which no architect, engineer, contractor, building inspector or economic entomologist in sections where termites are troublesome can afford to be without. The authors and their associates are to be congratulated upon this comprehensive, well prepared and excellently illustrated contribution to applied science.

E. P. FELT

Horticultural Inspection Notes

J. Carl Dawson has been appointed State Plant Officer of Missouri in place of Dr. K. C. Sullivan.

The Bureau of Plant Quarantine on December 1 issued a synopsis of the plant quarantine import restrictions of the Republic of Argentina.

During the year 1933 the States of Idaho, Georgia, and Wyoming discontinued terminal inspection of parcel post shipments of plants and plant products.

Earl Hutchings, Agricultural Inspector of the Utah State Board of Agriculture, has been placed in charge of the Bureau of Plant Industry of that Department in place of F. E. Stephens, formerly State Agricultural Inspector.

W. C. Jacobsen, Supervisor of Rodent and Weed Control of the California State Department of Agriculture, has in addition to his work in that capacity been assigned the position of Administrative Assistant in the office of the Director of the Department.

Prof. A. G. Ruggles, State Entomologist of Minnesota, spent the first week of January in Washington, conferring with representatives of the Bureaus of Plant Quarantine, Plant Industry, and Entomology, on work in Minnesota in which his office is collaborating with the Federal Department of Agriculture.

The Pennsylvania quarantine relating to the gypsy moth infestation in that State was amended, effective December 15, to apply to Madison Township, including the borough of Moscow, in Lackawanna County. The entire regulated area in Pennsylvania now covers 8 townships and 1 city in Lackawanna County and 10 townships and 2 cities in Luzerne County.

The checking of mail, express, and freight at Pittsburgh to be sure of compliance with the Japanese beetle quarantine regulations, was discontinued for the winter in December. Mr. H. L. Dozier who had been carrying on this work was appointed to supervise mosquito control activities in Louisiana, under the direction of W. E. Anderson, State Entomologist.

According to the Bureau of Plant Industry, a considerable number of trees infected with the Dutch elm disease have been found in native woods west of Newark, N. J. It has been found practicable to make surveys for this disease during the winter months and a considerable number of men are employed in this work under an allotment from the Federal Civil Works Administration.

Luis A. Catoni, Chief Inspector of the Plant Quarantine Service of the Department of Agriculture and Commerce of Porto Rico, reports that a number of changes have recently been made in the personnel of his office. The present organization working under his direction include Sr. Jose Luciano, as Assistant Chief Inspector, and Srs. Correa, Colon, Collazo, Gauthier, Tolosa, Salas, Bofill, Figueroa, and Salazar, as deputies.

Wendell P. Brown, Supervisor of Horticulture of the Washington State Department of Agriculture, reports various changes in the horticultural inspection organization during the past year. The list of horticultural inspectors-at-large at present is as follows: S. R. Kelso, Walla Walla and Prosser; Hugh J. Wood, Spokane; Doyle B. Starcher, Wenatchee; Arthur C. Rich, Yakima; Chapin A. Mills, Vancouver; Wm. H. Shaw, Seattle; and Robert B. Clemens, Okanogan.

A part of the State of Idaho was released from the alfalfa weevil quarantine of the State of Washington under a revision dated November 7. The Idaho area now includes "all those counties lying south of the counties of Idaho and Lemhi." No changes were made in areas designated as infested in other States. Immigrant movables, household goods, camping effects, and automobiles were dropped from the list of restricted articles, and the former provision requiring carriers to hold for inspection articles admissible under the quarantine was discontinued. "Chopped hay" is now restricted in the same manner as alfalfa meal.

A revision of the Federal Japanese beetle quarantine which became effective on December 1 added parts of the States of Maine, Maryland, New York, Virginia, and West Virginia, to the regulated areas. The restrictions on shipments remain approximately the same except for the exemption from the certification requirement of ground, dried, imported peat in packages of five pounds or less to the package.

An infestation of the European potato wart was recently found in and near the town of Henry, Grant County, W. Va., bordering on Maryland, and the State quarantine on account of this pest was extended, effective October 13, to include that area as well as an area at Dobbin. The Pennsylvania quarantine relating to the wart was revised, effective December 11, making "limited changes * * * to permit planting of varieties other than immunes in certain isolated areas where wart infection is light, and where steps are being taken to eradicate the wart disease."

The certification of nursery stock and other products regulated under the Japanese beetle and gypsy moth quarantines has been combined under one organization under the direction of L. H. Worthley, who has heretofore been in charge of the Japanese beetle quarantine work. All other suppression activities against the gypsy moth, including the eradication of the Pennsylvania and New Jersey outbreaks, the maintenance of the barrier zone and emergency activities east of the barrier zone, continue to be carried out under the direction of Mr. A. F. Burgess, with headquarters at Greenfield, Mass.

Federal allotments to Virginia under the Civil Works Administration have provided for the employment, under the supervision of the State Department of Health of approximately 1,000 men on mosquito drainage activities in the Norfolk-Hampton Roads area. One man has also been assigned to make a survey of the species of Ribes in the State in anticipation of the starting of a campaign of Ribes eradication for the protection of white pine stands. Mr. G. T. French, State Entomologist, reports that applications have also been made for emergency allotments for the eradication of cedar trees in apple-producing areas and for the eradication of barberries to control black stem rust of small grains in the southwestern counties of the State. An unusual amount of rust in the orchards last year resulted in more interest in cedar eradication than has been manifested heretofore.

Last spring the Virginia State Department of Agriculture set up an extensive organization to take care of inspections required for all Irish potatoes originating in Virginia and consigned to Michigan points. This organization became necessary as a result of the issuance of a tuber worm quarantine in Michigan under which it was necessary to inspect a crop before harvesting and again at the time of digging. A cooperative arrangement was made with the State Division of Markets and the inspections were handled on a fee basis. The Truck Experiment Station at Norfolk also cooperated in making field surveys. Little trouble was experienced with the tuber worm this year according to Mr. G. T. French, State Entomologist, and since potatoes were in demand, the crop moved rapidly and was not stored on the farms or in freight cars awaiting shipment.

Dr. W. A. Taylor, Chief of the Federal Bureau of Plant Industry, under date of December 1, 1933, established a new division of plant disease eradication and control in that Bureau, to include the field operations heretofore carried out by the Bureau of Plant Industry under the projects of barberry eradication, blister rust control, citrus canker eradication, Dutch elm disease control, and phony peach eradication. Dr. K. F. Kellerman was placed in charge of this division, the memorandum stating that thereafter he would "report directly to Mr. Lee A. Strong, Chief of the Bureau of Entomology and Plant Quarantine." Dr. Taylor's memorandum continued: "It is expected that on July 1, 1934, the appropriations concerned will be consolidated with

the appropriations for the Bureau of Entomology and Plant Quarantine, of which the Division of Plant Disease Eradication and Control will then be a unit."

The Utah State Board of Agriculture, on August 3, rescinded all rules and regulations formerly in effect and issued new ones under the revised statutes of 1933. Among the more important changes in the nursery stock regulations is the discontinuance of the bond requirement and substituting therefor the license and fee of $5.00. The quarantine modifications include (1) the acceptance of potatoes from Texas when certified to show they are either fumigated or have come from a district free from the tuber moth; formerly fumigation was required in the case of shipments from any part of Texas; (2) designating as infested with the Colorado potato beetle all sections of the Western Continent except Utah, Nevada, California, 27 counties in Idaho (formerly 18), and 2 in Arizona (formerly 12); (3) designating as infested with the cherry fruit fly 20 counties in Washington (formerly 2), 14 in Oregon (formerly 30), and 2 in Idaho (formerly 3); (4) adding to the area designated as infested with the Oriental fruit moth, the States of Kansas, Massachusetts, Michigan, Missouri and Rhode Island; and (5) placing a complete embargo on articles restricted under the quarantine relating to the European corn borer. The quarantine relating to the pecan leaf casebearer was reissued without change, "pending further investigation to definitely determine the status of the insect."

A revision of the pink bollworm quarantine was issued by the Secretary of Agriculture, effective December 23, bringing under restriction parts of three counties in Georgia and adding four entire counties and parts of three other counties in Texas, one county in Florida, and two counties in New Mexico, to the regulated areas of those States. Under the same revision the Salt River Valley of Arizona was released from restriction. The Department stated in connection with the release of the Salt River Valley that an extermination program carried out in that region for the past four years has apparently been successful since no pink bollworms were discovered in either the 1932 or 1933 crops. This infestation was originally found in October 1929, and by 1930 the insects were discovered to be widely distributed throughout the valley. Suppression measures included creation of noncotton zones, field cleanups, the restriction of planting dates, seed sterilization, and other requirements. The only counties remaining under the pink bollworm quarantine in Arizona under the new revision are Cochise, Graham, and Greenlee, in the southeastern corner of the State.